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THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JANUARY · 1914

The Worth of Each Member

HAVE you ever considered the value of your membership? Some members can do more for the Society than others, but it is upon the interest exhibited by each individual that the Society depends for the achievement of its aims and purposes.

Every member is encouraged to participate in some way which will make for the continued growth and prosperity of the profession of engineering.

The work carried on under the direction of the Committee on Increase of Membership affords opportunity for every member to coöperate. It is hoped to obtain the membership of all technical men in authority in every industry who have the necessary qualifications for membership.

Personal solicitation by the members is the only way in which engineers of the highest attainments may be reached. There are many such men who would be glad to participate in the work which is being done if the matter were brought to their attention personally.

Such interest and coöperation by every member would make the Society completely representative of every branch of industry and equipped to undertake all problems bearing upon the development of engineering.

THE COMMITTEE ON INCREASE OF MEMBERSHIP

For members of Committee see page LIX.

Total Membership of the Society, December 15, 1913 . . . . . *5267*

Net Increase in Membership Since January 1, 1913 . . . . . *725*

JAMES HARTNESS
PRESIDENT 1914
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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Volume 36 JANUARY 1914 Number 1

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COMING MEETINGS OF THE SOCIETY

January 9, New York City, Engineering Societies Building. Joint meeting with the American Institute of Electrical Engineers and the New York Section of the American Electrochemical Society. Subject: The Power Problem in the Electrolytic Deposition of Metals: Papers, The Limitation of the Problem, Lawrence Addicks, A.E.S.; The Mechanical Side of the Problem, H. E. Longwell, Am.Soc.M.E.; The Electrical Side of the Problem, F. D. Newbury, Am.Inst.E.E. The American Institute of Electrical Engineers will give a smoker in their rooms at the close of the meeting, to which the membership is invited.

January 17, Philadelphia, Pa. Joint meeting with the Engineers Club of Philadelphia. Subject: Some Recent Improvements in Steam Locomotives, George R. Henderson.

February 3, Boston, Mass. Subject: Railroad Rolling Stock, Electrical Equipment and Permanent Way, recent developments and present tendencies: papers by Henry Bartlett, Frederic B. Hall, A. B. Corthell.

February 14, Milwaukee, Wis. Subject to be announced.

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THE NEW JOURNAL

The Journal appears this month in an enlarged form, with a new arrangement of its material and new matter added. As already announced, this comes as the result of a long and careful study by the Publication Committee of the whole question of the publications of the Society, made at the request of the Council.

In considering the problem a forward look has been taken into the possibilities of The Journal as the publication of a great engineering society, whose membership is rapidly increasing and whose activities are extending in many directions. These possibilities appear to be very great and the service which may eventually be rendered to the membership almost invaluable. Local meetings of the Society are now held in twelve cities, and the Annual and Spring Meetings are so filled with professional papers that it is necessary to hold simultaneous sessions; while the other active work of the Society has grown to such an extent that its various committees have over 300 names on their rolls. These facts suggest the possibilities in the way of papers, discussion and reports of varied character for publication in The Journal, and the comprehensive way in which the broad field of mechanical engineering is destined to be covered through the resources of the Society alone. Add to these the resources of the Engineering Societies Library, outlined in a separate article in this number, and the opportunity for bringing the library closer to the membership through reviews of its periodical literature, and a suggestion may be had of what The Journal may eventually accomplish for the Society and its members and the cause of mechanical engineering in general.

PLAN FOR THE SOCIETY'S PUBLICATIONS

It has long been evident that the duplicate publication of papers and discussion, first in The Journal and later in Transactions, was an economic waste not in accord with good engineering practice. It is proposed to avoid this duplication by having The Journal contain the Transactions, the material of which will be arranged with this end in view. In this respect the Society will be following the custom of the leading European engineering societies, including the Verein deutscher Ingenieure, and of the American Medical Association in this country. The journals of the Verein and of the American Medical Association are the most successful professional journals in the world.

Under the present plan of publication papers for the Annual and Spring Meetings are to be printed in pamphlet form, complete, in advance of the meeting, but not published in The Journal prior to the meeting. In order that the membership may be advised of the papers that are to be presented, however, abstracts of papers for a coming meeting will be grouped and published in one number of The Journal one month in advance of the meeting, and copies of the complete papers on any subject will be sent gratis to members asking for them.

Papers and discussion will be published together in issues of The Journal following the meeting at which they are presented. By this procedure, the papers and discussion will be brought together instead of being separated as has previously been the case in The Journal. The revised papers and discussion will thus appear at an earlier date than is possible in the annual volume of Transactions, and will constitute the Transactions of the Society in a permanent form for binding and preservation by the membership. While it has not recently been possible to include all the papers and discussion in the annual volume of Transactions owing to the necessity of keeping this publication within the limits of a single volume, The Journal can probably contain all this material and be a complete instead of a partial record of the various meetings of the Society.

THE NEW SIZE FOR THE JOURNAL

The 9 by 12 size which is now adopted for The Journal is the standard toward which the technical journals are tending. Already 144 of the publications received in the Engineering Societies Library are of this size, and many others approximately so. A larger page than the 6 by 9 size heretofore used has been much needed in order to present properly the articles.

which have to be handled without the use of the always inconvenient folders and inserts. An example of this is to be found in this number in the report on flanges, which has tables and diagrams that would be altogether too small if reduced to the size of the smaller page.

The larger page also allows a more attractive presentation of the matter; the text can be more easily read because of the narrower columns and the page appears more inviting because there are more text and illustrations under the eye at one time. The Journal in this form will further be more economical to produce because there are fewer units to handle; and it will allow the advertiser a more effective display and so increase the advertising income. All of this income is used for the production of The Journal, absolutely none being spent on Society activities.

Substantially the 9 by 12 size is used by such professional societies of the world as the Verein deutscher Ingenieure and many other leading continental societies; by the Institution of Naval Architects, the American Medical Association and the American Society of Naval Architects; and has recently been adopted by the American Institute of Architects and the Institution of Electrical Engineers of Great Britain. It allows a freer scope in the conduct of a journal and is one of the important elements in its successful production.

REVIEW OF ENGINEERING SOCIETIES

In the present number of The Journal there has been begun a review of the proceedings of engineering societies, in addition to the Foreign Review previously published. The proceedings of 132 societies are received in the library, and much of this material would not be available to the membership except through a review such as is now being undertaken. While it is hoped that this department may be extended and other improvements made in The Journal, the development must necessarily be gradual, and within the available income.

ARRANGEMENT OF THE JOURNAL

As now printed, The Journal is made up in sections which can be readily separated to facilitate binding. The reports of meetings and engineering matter of greatest value for permanent record are contained in two middle sections, each numbered on a different system to avoid confusion in indexing.

The first of these sections contains papers, discussion and reports of meetings, equivalent to what is now included in the annual volume of Transactions, only, as already explained, it will be more complete. This section will therefore constitute an improved Transactions and can be bound up separately as such if desired.

The second section referred to consists of the Foreign Review and the Review of the Proceedings of Engineering Societies, which can also be bound separately, or, if preferred, the twelve review parts of a year's volume can be grouped and bound together at the back of the volume of Transactions.

Two other sections, constituting the beginning and end of the reading pages respectively, are of less permanent value or of a less technical nature. If a member desires to reduce the size of his bound volume to the lowest limit, he can discard these first and last sections without losing any of the essential engineering data. At the end of the year suitable indexes will be issued, with directions for binding.

Referring to the present number, the Transactions part begins with the report of the Annual Meeting, following which is the review part and after that certain miscellaneous matter which many may wish to discard. At the very front is other miscellaneous matter among which is a report on Flanges, which was not included in the Transactions part because it is to come up again for further discussion and so is subject to revision.

COPIES SHOULD BE SAVED FOR BINDING

Every member of the Society should keep his copies of The Journal for binding at the end of the year. The Journal now comprises the only complete record of the Society's affairs. While a volume of Transactions will be issued this year as usual, to contain the papers and discussion for the year 1913, it is intended thereafter that The Journal shall take the place of Transactions and in order to insure the continuity of the bound volumes all the copies of The Journal for the present year should be saved for binding. As a personal matter, if a sufficient number of members express a desire for copies of Transactions in the original form with the small page, an edition will be printed and sold at cost.

NEW OFFICERS OF THE SOCIETY

JAMES HARTNESS

President of the Society for 1914

James Hartness, President of The American Society of Mechanical Engineers for the year 1914, was born in Schenectady, N. Y., in 1861. The first twenty years were spent at Cleveland, Ohio, where after graduating from the public schools he began practical work in machinery building plants. For the next three years he held a position as foreman of a manufacturing plant in Winsted, Conn., and for the four years following, was with a hardware manufacturing plant in Torrington, Conn., where he finally served as inventor.

In the fall of 1888, Mr. Hartness designed machinery for the Jones and Lamson Machine Company at Springfield, Vt., and shortly afterward took an active part in the management of this company. He served successively as superintendent, manager and, for the last dozen years, as president. During this period he has become one of the most prominent manufacturers in New England and one of the most widely known engineers in the country, particularly in the machinery building industry, through the invention and manufacture of the Flat Turret Lathe and of various other machines and tools for turning metal. The fundamental idea in these machines has been to produce certain kinds of work, generally classed as engine lathe work, with greater expedition and economy than could be accomplished with the engine lathe. He has taken out in all over eighty American patents on his various inventions.

The Jones and Lamson Machine Company with which Mr. Hartness' engineering success has been associated, was formerly the old Robbins and Lawrence Company, started at Windsor, Vt., over sixty-five years ago. They originally built a general line of machine tools, but gradually specialized on turret lathes, so that the history of this firm appears to be practically the history of the turret lathe itself from its very beginning. Various features now in common use were developed from time to time until about 1882 when the turret lathe had practically become standardized in the form of the present high turret machine of commerce with the various features of power-feed, lever-operated back gears, etc., and was being built in sizes that were very large for those times. It was then tending to find its work in the engine lathe field rather than in strictly screw machine work.

The turret lathe remained stationary in its development at this point for several years, until Mr. Hartness' connection with the concern which began in the fall of 1888. He at once saw the possible development of the turret lathe, and inaugurated a series of improvements which brought it into the field of bar and shaft work of a kind that had previously been considered engine lathe work pure and simple.

In studying the problem he considered the merits of three forms of turrets,—the disk turret, the barrel turret, and the flat turret. He found that the disk turret had been anticipated by the Gray turret lathe built on a small scale some years previously in Alabama. He patented the barrel turret, but did not consider it as the most practical form for use in the hands of workmen with no especial training for the machine. The flat turret appealed to him as meeting the requirements in a practical way for a broad extension of the turret lathe field, making possible the turning of long pieces, such as shafts and spindles, etc., from the bar with an accuracy and rapidity not previously possible. The form of the turret permitted a firm tool surface on which the specialized turning tools could be clamped; and what was especially important, permitted the locating of the locking pin directly under the cutting tool, instead of on a very much smaller diameter, as with the old-fashioned form of turret. The turret was also gibbed at the outside on a larger diameter than the location of the cutting tools.

The tools themselves were of original construction, embodying principles now universally used in all turret lathes for doing bar work. The principal feature of the improvements was the provision of adjustable blades and back rests in the same holder to which the severe strains of cutting were thus confined without permitting deflection and lack of truth, even in turning of the most slender variety.

One interesting feature of Mr. Hartness' first work on the flat turret lathe may be mentioned. He was working on a certain important detail of turret lathe construction, and after a long study had settled on a certain form of mechanism as being the logical construction. In looking through the archives of the firm, he found a sketch of the identical mechanism made many years previously by Mr. Fred Howe, who was the mechanical genius mainly responsible for the splendid line of original design brought out in the early history of the firm. After the first natural feeling of disappointment, Mr. Hartness took courage from the thought that he had come to the identical conclusions reached by this thoroughly skilled and original mechanic of an earlier generation, and so continued his work in the development of what is now the flat turret lathe.

For several years Mr. Hartness has had as one of his pleasures the study of astronomical subjects and in 1910 he invented the turret equatorial telescope, which had as its very practical object the protection of the astronomer engaged in making observations from the

rigors of a cold winter climate. This end was attained without the serious optical loss that had been involved in previous designs, and is generally considered a marked step in advance which will have an important bearing on the results obtained by astronomers when working under severe climatic conditions. One of these instruments was built, and erected at his residence at Springfield, Vt., and formed the subject of a paper before the Society at the Annual Meeting of 1910.

As all of Mr. Hartness' friends and acquaintances know, he is a man of strong individuality, which shows in everything his hand touches. The machines he has designed could have been designed by no one else. They will be mistaken by no one for the work of another designer. The same applies to the business organization and methods of management of the firm of which he is the head. Many of these ideas have been set forth at some length in his book, the Human Factor in Works Management.

Previous to his election to the presidency of the Society, Mr. Hartness was a vice-president and in the absence of President W. F. M. Goss served in the capacity of president during last summer's trip through Germany. In every city visited he was called upon to address the German and American engineers.

Mr. Hartness became a member of The American Society of Mechanical Engineers in 1891. He is a fellow of the American Association for the Advancement of Science, and a member of the Institution of Mechanical Engineers, the Verein deutscher Ingenieure, the Astronomical and Astrophysical Society of America, the London Astronomical Society, the Royal Arts Society, the Boston Chamber of Commerce, and is a vice-president of the Western New England Chamber of Commerce. He was granted an honorary degree of M. E. by the University of Vermont in 1910.

NEW MEMBERS OF THE COUNCIL

At the Annual Meeting the following new members of the Council for 1914 were elected: Vice-Presidents, Henry L. Gantt, E. E. Keller, H. G. Reist; Managers, A. M. Greene, Jr., John Hunter, Elliott H. Whitlock.

HENRY L. GANTT

Henry L. Gantt was born in Calvert County, Md., on May 20, 1861, and was graduated from Johns Hopkins University in 1880 with the degree of A.B. He then taught school for three years and took the degree of M.E. at Stevens Institute of Technology in 1884. He was connected with Poole & Hunt, Engineers and Machinists, in Baltimore, as draftsman, and conducted an extensive study of investigations to determine the cost of irregular melting of cast-iron in foundry cupolas. He was with the Midvale Steel Company, Philadelphia, for six years, and subsequently held positions as superintendent of the American Steel Casting Company and the Simonds Rolling Machine Company, and was later with the Bethlehem Steel Company and the American Locomotive Company.

Since 1903 he has been in consulting practice, engaged in introducing shop management methods. This work which has become his specialty actually began in 1887 when he was engaged at the Midvale Steel Works, under F. W. Taylor, studying the laws of cutting metals, and reducing them to curves by which he was able to make instructions and set piece rates for cutting steel.

In 1899 he took up the same work with Mr. Taylor at the Bethlehem Steel Works, and put these laws on a slide rule, making them more readily available for giving instructions and setting tasks for cutting steel. In 1901 he devised the system of task work with a bonus, and at the Annual Meeting of the Society in that year read his paper on a Bonus System of Rewarding Labor.

The results of this system far exceeded all anticipation. Working at a task with a reward for its accomplishment seems to have a psychological effect when the task is within the workman's reach, and stimulates a much greater interest than piecework does, with a corresponding benefit to both employer and employee.

For the past few years Mr. Gantt has been engaged in perfecting a system of management which would lead employees of all grades to become interested in their work. One result has been the development of a strong spirit of harmony and coöperation among employees working under his instructions, but which is so strong as almost to eliminate jealousy among those engaged in the work. The most striking effect, apart from the improvement in quality and increase in quantity of product, has been the development and training of men. It is seldom now in plants working under these methods that a trained man promoted to a higher position does not fill it better than his predecessor did.

Mr. Gantt has presented a number of papers on his work before this Society and others, the principal ones being that mentioned on a Bonus System of Rewarding Labor; A Graphical Daily Balance in Manufacture, read before the Society in 1903; and Training of Workmen, read in 1908. He is also the author of Work, Wages and Profit, published in 1910, and which has recently been enlarged in a new edition.

While at the Bethlehem Steel Works Mr. Gantt developed an armor-piercing projectile and established its manufacture. After an extensive series of experiments on a laboratory scale, he produced four 8-inch projectiles, all of which passed the Government tests. No projectile submitted for test failed to pass it.

E. E. KELLER

E. E. Keller was born in New York City on October 16, 1863, and was educated in the New York and Rochester public schools, where his parents removed when he was seven years old. On leaving school he obtained employment with the Yawman & Erbe Com-

Henry L. Gantt, Vice-President

E. E. Keller, Vice-President

A. M. Greene, Jr., Manager

H. G. Reist, Vice-President

John Hunter, Manager

Elliott H. Whitlock, Manager

pany, studying mechanical and electrical engineering in his spare hours.

In 1888 he entered the employ of the Westinghouse Company in Pittsburgh, and within three months was given charge of all the construction work in the Pittsburgh district. Three months later he was made manager of the Chicago office and placed in charge of the construction work of that district. At the beginning of the work on the World's Columbian Exposition in 1891 he received the appointment of electrical engineer for the department of electricity of the exposition commission, carrying this in conjunction with his other work.

In July, 1892, he gave up this special work for the exposition in order to devote all his time to the work to be done under the contract secured by his company for the lighting of the buildings, exhibits and grounds of the fair, the largest single electric lighting construction contract ever undertaken up to that time, with only a little more than a year's time in which to complete the work. It included all the installation of plant, underground and interior work, decorative lighting, and the operation before, during and after the exposition period, as well as the final removal and disposal of the installation. Mr. Keller's marked success in this work resulted in his being offered the position of vice-president and general manager of the Westinghouse Machine Company, then a comparatively small organization building single acting steam engines only.

In 1895 Mr. Keller went to Europe to investigate the steam turbine and bought the United States patents and rights covering the Parsons steam turbine for his company. The following year he began the construction of the present large plant at East Pittsburgh to take care of increased business and the construction of steam turbines and gas engines, which during the fifteen years in which he occupied the office of vice-president and general manager expanded the business to its present large proportions.

In 1907 he was made one of a board of receivers for the Westinghouse Machine Company and carried on the active executive management for the receivers until the property was returned to the stockholders in March, 1908. Mr. Keller severed his connection with the several Westinghouse interests in 1908, and began to devote his time to his personal interests in Detroit and elsewhere.

He organized the Detroit Insulated Wire Company, of which he became its president in 1906, and three years later removed to that city in order to look after the interests of the company and those of the Metal Products Company, of Detroit, of which he was also president. Both companies soon became successful, but owing to the pressure of other interests, Mr. Keller severed his connection with them some time ago. He is now actively connected with several other manufacturing enterprises of Detroit and elsewhere, which, however, are of lesser importance.

Mr. Keller is a member of the American Institute of Electrical Engineers and of the Verein deutscher Ingenieure, as well as a member of other engineering and technical societies.

HENRY G. REIST

Henry G. Reist was born near Mt. Joy, Lancaster County, Pa., May 27, 1862, and received his technical education at Lehigh University, from which he was graduated in 1886 with the degree of M. E. The same year he entered the employ of the foundry and machine department of the Harrisburg Car Company, and was engaged in the manufacture of Ide engines and road rollers. After a year of testing and erecting steam engines, he became assistant superintendent.

He went abroad with the Society in 1889, and upon his return became associated with the Thomson-Houston Electric Company, at Lynn, Mass., advancing in a few months to the position of foreman of the winding and testing department. Soon after the formation in 1894 of the General Electric Company, successor to the Thomson-Houston Electric Company, he took charge of the design of alternating-current generators and motors for that company, and at present occupies the position of mechanical engineer for the same firm.

Mr. Reist helped to develop the first large belt-driven railway generators, and for about fifteen years has been identified with the design of alternating-current machinery. Much of the largest and most important electrical machinery has been designed under his direction. He is a member of the American Institute of Electrical Engineers, and of several other technical organizations.

ARTHUR M. GREENE, JR.

Arthur M. Greene, Jr., was born in Philadelphia, Pa., February 4, 1872, and was educated in the public schools of that city, and at the University of Pennsylvania, from which he was graduated with the degree of B. S. in 1893 and with that of M. E. in the following year. During his college course he was the recipient of a number of honors.

In 1893 he took charge of the apprentice school of the Franklin Sugar Refinery, and the following year became an instructor in Drexel Institute, receiving an appointment in the department of mechanical engineering of his alma mater in 1895. He remained in this work until the year 1902, when he resigned to become professor of mechanical engineering and later junior dean of the school of engineering of the University of Missouri. In 1907 he came to the Rensselaer Polytechnic Institute in Troy as professor of mechanical engineering, the position he now occupies.

Professor Greene has been active in his profession in various lines. He was a member of the committee of science and the arts of Franklin Institute from 1895 to 1902, was mechanical engineer for the National Export Exposition in Phila-

delphia in 1899 and a member of its jury of awards, and made the original plans for the equipment of the new mechanical engineering laboratory of the University of Pennsylvania. His work at the University of Missouri included charge of the mechanical engineering equipment of the new laboratories, and he was also in charge of the power plant and maintenance department. At Rensselaer he has also supervised the new laboratories.

He is an expert in court and patent cases, and is the author of several books on heating and ventilation, pumping machinery and steam engineering. He is a fellow of the American Association for the Advancement of Science and is now president of the Society of Engineers of Eastern New York.

JOHN HUNTER

John Hunter was born in Scotland in 1866 and was educated in the public schools, serving his apprenticeship as a mechanical engineer before leaving Scotland.

The first twenty years of his career were spent in marine service. In 1885 he joined the Red Star Line, S. S. Westerland, as junior engineer, sailing between Antwerp and New York, rising to first assistant of the S. S. Friesland of the same company in 1891. In 1895 he transferred to the new S. S. St. Louis of the American Line, running between New York and Southampton, as senior first assistant engineer, and at the outbreak of the Spanish-American war in 1898 was appointed chief engineer of the S. S. St. Paul with the rank of lieutenant, U. S. A.

The St. Paul was taken over by the United States Navy, equipped as an auxiliary cruiser, and fitted with twenty 5-inch guns, and under the command of Admiral Sigsbee saw much active service during the war, which bore heavily on the crew. When the St. Paul went back in the North Atlantic service, Mr. Hunter continued as chief engineer until August 1905 when he gave up his naval career to enter consulting work. During his twenty years of sea service he had traveled 1,500,000 sea miles, and had seen an interesting development in marine engineering. The steam pressure carried on boilers in his ships had risen from 10 to 200 pounds, and the old low-pressure engines had given place first to the cross-compound type, with 80 pounds pressure, then to the triple expansion three-cylinder engine with 165 pounds, and finally to the six-cylinder quadruple expansion engines and twin screws of the St. Paul, with their 200 pounds pressure.

In August, 1905, he went to St. Louis to take the position of chief engineer of the power plants of the Union Electric Light and Power Company. At that time the Ashley Street plant was under construction, and changes were being made to increase the capacity of the station. In the early part of 1907 he was given charge of the construction work of the company and the completion of this plant, including the last section of the east river wall where it was found necessary to sink two caissons to bed rock, 22 feet below the zero stage of the river. He is also in charge of the steam heating plant of the company.

Mr. Hunter has been prominent in the affairs of national societies, having served for three years as a member of the prime movers committee of the National Electric Light Association, and is now president of the Engineers Club of St. Louis. He also served two years as president of the Caledonian Society.

ELLIOTT H. WHITLOCK

Elliott H. Whitlock was born in Brooklyn, N. Y., on May 5, 1867, and after attending the public schools entered the mechanical department of the State College in Texas, where his brother was a professor of mechanical engineering. He was graduated with the degree of B. S. in 1886, and in the fall of the same year entered Stevens Institute of Technology, receiving the degree of M. E. in 1890.

Mr. Whitlock's first work was with the Pennsylvania Railroad Company, in their motive power department, as a special apprentice in the Columbus, Ohio, shops. He left this position in 1891 to occupy the chair of mechanical engineering at the State Agricultural and Mechanical College in Brookings, S. D., remaining until 1893 when he entered the employ of the Williamsburg Gas Light & Coke Company of Brooklyn. He subsequently was with the United Gas & Improvement Company of Philadelphia, in their construction department, and manager of the New York Oxygen Company, New York City.

About this time Mr. Whitlock engaged in retail business in Cincinnati, acting as president of a concern handling gas appliances. That his interests were still along mechanical lines, however, is evidenced by the small ice machine which he developed incidentally during this period. He was for a short time manager of the King Axle & Tool Company of Cleveland, and in 1896, connected himself with the National Carbon Company, of which he is at present factory manager.

Mr. Whitlock has had a patent issued on an improvement on a drop hammer and also one on a new type of oil gas retort using vertical cast-iron retorts. The development of this latter idea led Mr. Whitlock to construct a plant which is still in operation.

THE ENGINEERING SOCIETIES LIBRARY

ONE of the largest collections of engineering literature in the world is housed in the Engineering Societies Building, at 29 West 39th Street, New York, the headquarters of The American Society of Mechanical Engineers. It is made up of the joint libraries of the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and the American Institute of Mining Engineers, and contains more than 65,000 volumes of great technical value, including, besides all the important works in these three fields of engineering, many books of reference, the bound sets of the proceedings of practically all the engineering societies of the world in these fields, and of many others allied with them. Some of these sets cannot be found in complete form in any other library in the country.

The library also receives every important engineering periodical of the world in the mechanical, electrical and mining fields, as well as many others covering chemical technology and other allied industries, numbering in all more than 700 current magazines, printed in more than ten languages, which are now at the disposal of the reader.

The location of the library at the top of a great building is almost ideal, insuring as it does splendid lighting and the absence of dust and street noises. Its arrangement was planned with a view to making its contents accessible to readers, and only a few of the greater rarities are in locked cases, all the other volumes being on open shelves. Those most frequently called for are in the main reading room on the top floor, while the stack room on the floor below contains the ones less seldom referred to.

The main reading room, a photograph of which is shown herewith, is dignified in its simplicity. Three massive columns on each side separate the north and

south sides into spacious alcoves, where wide tables and comfortable chairs have been placed for the convenience of the reader. The mezzanine gallery recently erected, has increased the shelf space, and adds to rather than detracts from the general appearance. At the rear of the room, facing the visitor as he enters, is Frank Dana Marsh's fine mural painting depicting the operations of engineering. The central figure is that of the directing engineer, robust and keen-eyed, while on each side are brawny workmen handling machinery, drilling hard rock, running surveying lines, and erecting dynamos. In the background are railroads, bridges, blast furnaces, steel works—a Pittsburgh in miniature. A fine view of New York and its massive skyline can be obtained from the wide windows of the reading room.

Through the generosity of the members of the three societies which jointly maintain the library, supplemented by the annual appropriations of the societies of themselves, there has been accumulated this collection of technical literature of exceptional value. Among the volumes available are the publications, in their original editions, of the two oldest learned societies of the world, the Royal Society of London and the Academy of Science of Paris, the former dating from the time of Charles II of England. Electricity and magnetism are completely covered by the Latimer Clark Collection, presented in 1901 by Dr. Schuyler Skaats Wheeler, and through the kindness of Dr. Carnegie properly catalogued and housed. The great works of the mathematicians, physicists and chemists which are the basis of all engineering, are well represented.

The early work of the engineer is represented by many valuable works dating back to the beginning of the printing of scientific books, and the many volumes in Latin and mediaeval English form a nucleus of what, it is hoped, may in the future be a valuable source of information for the American engineer interested in the history of his profession.

But, however great may be the value of old books, the engineer of today wants the literature of today. The library is not a dry-as-dust museum. It has records of the past for reference when required, but it has in even greater profusion the literature of the immediate present. Every engineering periodical is accessible to readers as quickly as the mail can bring it to the library, and books are usually available before they reach the review columns of the engineering journals. Every work is catalogued and shelved as promptly as possible.

Through the gift of a lately deceased member of The American Society of Mechanical Engineers, the library has acquired one of the most complete collections in the world of works on machinery and appliances for handling and conveying materials of all kinds, and this collection is being expanded as rapidly as possible. In these days of large enterprises the literature of this subject is of enormous importance. An attempt is being made to cover every subject of contemporary interest in the same complete manner.

The 700 serial publications received from all parts of the world are for the most part preserved and bound. These are largely received in exchange for the publications of the founder societies. A list has been issued by the library showing the periodical sets which it contains, and a second list, in which will be shown the resources of seven libraries in New York and its vicinity, is being edited for publication. It is hoped that ultimately a list covering the libraries of the United States may be issued.

It is manifestly impossible for any engineer to collect, preserve and digest for himself the voluminous literature of his profession. He must depend on the work of others, reviewers, indexers, abstractors, and librarians. Until a very recent date a library considered its duty accomplished when it had acquired, preserved, catalogued, and indexed the literature of the subjects covered. A reader was forced to visit a library in order to get information. But the up-to-date library is adopting a new policy which makes complete service possible to students at a distance.

To be more specific, the library of the Engineering Societies is prepared to render the following service to any one who desires it:

(a) It will verify references, furnish abstracts, copies, and translations of any article from citations sent by an engineer or student.

(b) It will furnish partial or complete bibliographies of engineering subjects, and where the original sources are not available to the client, furnish either the original print, or such abstracts, copies, photographs and translations as are necessary.

During the period in which this service has been in operation, some 500 reference lists have been compiled, and copies have been retained and are available to any one. It is manifestly impossible to give here a complete list of the subjects covered; it can only be said that nearly the whole engineering field is covered. A list covering such a search on the subject of Pulverized Fuel is printed in this issue of The Journal. The library keeps a card index of the important articles in the current periodicals and society publications as it receives them, so that the inclusion of the literature of the minute is assured in the reference lists.

This special service is particularly commended to the attention of engineers in isolated places. Its international scope is evidenced by the fact that during the past two years it has been of assistance to engineers in such far-off countries as Patagonia, Korea, Japan, South Africa, Germany, and Australia. References have also been sent to Alaska, British Columbia, Mexico, and the Canal Zone. In the improbable event that a reference is not found in the library,

books are borrowed from other libraries, either in New York or other cities. When transcripts of articles are desired, photographic copies are preferable in most cases, as being cheaper than typewriting and a guarantee against mistakes.

The library is a general bureau of information for engineers. It will furnish addresses of engineers, names of publishers of books and periodicals, addresses of manufacturers, and statistics of various kinds. It also has facilities for accurate technical translation. Requests by telephone, telegraph and cable will receive immediate attention.

A nominal charge (net cost) is made for this service, based on the following rates: for research or copying, fifty cents per hour; for translations, twenty-five cents per one hundred words for French and German, and thirty-five cents for other European languages. Photographs, made white on black, direct on paper, cost thirty cents for each 11 in. by 14 in. sheet, which may cover two opposite pages either full size or reduced.

The relation of the library and the engineer should be a reciprocal one. The engineer may help the library and his fellow engineers in several ways. He may give books, or money to buy them; he may send trade catalogues, maps and blueprints. He may suggest new books for purchase. If he wishes to indulge in adverse criticism, he should direct it to the librarian, who welcomes suggestions of improvement, even if unpleasantly critical. The library is the property of the engineer, and not of the librarian, and the librarian can best serve the engineer who knows what he wants, makes it specifically known, and complains specifically and directly of disappointments.

W. P. Cutter, *Librarian*

COUNCIL NOTES

At the meeting of the Council on December 5, the following committee on meetings in San Francisco was approved: Robert Sibley, Chairman; Thomas Morrin, Vice-Chairman; C. T. Hutchinson, Secretary; E. C. Jones and C. R. Weymouth.

The Secretary read a letter from Dr. Charles E. Lucke, recommending the appointment of engineers to commissionerships in national, state and municipal departments involving engineering work, and a resolution was passed by the Council approving the suggestion and also the recent action of the American Institute of Consulting Engineers favoring such appointments. The matter was then referred to the Joint Conference Committee for further action.

The following were appointed to act as a Committee on Standardization: Henry Hess, Chairman; J. H. Barr, Charles Day, C. J. Davidson and Carl Schwartz. A resolution was passed by the Council to amend the Constitution to make the committee on standardization a Standing Committee.

At the meeting of December 5, Calvin W. Rice and Frederick R. Hutton were reappointed respectively Secretary and Honorary Secretary of the Society, and E. B. Katte was elected Vice-President to fill the unexpired term of James Hartness. The following Executive Council was appointed: James Hartness, Chairman; Alex. C. Humphreys, Vice-Chairman; E. D. Meier, H. L. Gantt, E. B. Katte, Alfred Noble, and H. G. Stott. Dr. Alex. C. Humphreys was reappointed trustee of the United Engineering Society, and Ambrose Swasey chosen as the representative of the Society on the John Fritz Medal Board of Award.

The Council was addressed at this meeting by a representative of the Verein deutscher Ingenieure, Geheimrath Fr. Romberg, on the solution of important questions in technical and industrial education. His offer, on behalf of the Verein, to present a set of volumes covering that organization's report on technical schools was accepted with thanks.

Calvin W. Rice, *Secretary*

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i. e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are under twenty-five years of age and therefore qualified for Junior grade only. The Membership Committee and in turn the Council urge the members to assume their share of the responsibility of receiving these candidates into the membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before February 10, 1913.

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Allen, Frank L., Rep., Marshall & Huschart Mchy. Co., Chicago, Ill.

Anderson, Arthur H., Asst. Prof., Mech. Engrg., Armour Inst. of Tech., Chicago, Ill.

Arnold, Henry F. W., Plant Engr., The Jeffrey Mfg. Co., Columbus, Ohio

Bates, James H. S., Cons. Engr., 118 P. O. Box, Hoboken, N. J.

Bird, Frederick J., Engr., Link-Belt Co., Chicago, Ill.

Blanding, Forrest H., 1300 College Ave., Racine, Wis.

Boomhower, Frederick K., Ch. Engr., Insurance Exch. Bldg., Chicago, Ill.

Buckingham, Edgar, Assoc. Physicist, Bureau of Standards, Washington, D. C.

Bunton, F. L., Dist. Mgr., Heine Safety Boiler Co., Chicago, Ill.

Burrow, Edgar A., Ch. Engr., San Angelo Water, Light & Power Co., San Angelo, Texas

Clark, Lawrence A., Secy. and Treas., Archer Iron Wks., Chicago, Ill.

Converse, Wm. A., Secy. and Chem. Dir., Dearborn Chemical Co., Chicago, Ill.

Cooper, Frederick F., Genl. Mgr., Golden States & Miners Iron Wks., San Francisco, Cal.

Cox, Abraham B., Asst. Engr., General Reduction, Gas & By-Products Co., 49 Wall St., New York

DeWolf, Roger D., Mech. Engr., Rochester Rwy. & Lt. Co., Rochester, N. Y.

Ehrhart, Raymond N., Engr., Westinghouse Mch. Co., E. Pittsburgh, Pa.

Erdell, William E., Pres. & Genl. Mgr., Penn-Allen Cement Co., Allentown, Pa.

Fortuin, Morris, Wks. Mgr., Pennsylvania Cement Co., Bath, Pa.

Gayman, Bert A., Asst. Ch. Engr., Link-Belt Co., Chicago, Ill.

Goettsch, Julius, Asst. Genl. Supt., D. H. Burnham & Co., Chicago, Ill.

Grady, Charles B., Asst. Mech. Engr., N. Y. Edison Co., New York

Gustafson, Lewis, Supt., David Ranken, Jr. Sch. of Mech. Trades, St. Louis, Mo.

Hart, Charles F., Mech. Engr., Assoc. Newspapers, Ltd., London, England

Hawkins, Thomas U., Master Mech., Mutual Chem. Co. of Amer., Jersey City, N. J.

Hill, George F., Engr. & Contr., 15 E. 40th St., New York

Johnson, Wilner E., Engr., Car Constr., N. Y. Municipal Rwy. Corp., Brooklyn, N. Y.

Kammann, Franz, Ch. Engr., Briegleb, Hansen & Co., Gotha, Germany

Karl, Robert H., Asst. Supv. Engr., Anheuser Busch Brewing Asso., St. Louis, Mo.

Knobloch, Alvin F., Vice-Pres. and Genl. Mgr., Northway Motor & Mfg. Co., Detroit, Mich.

McCauley, Louis G., Mech. Engr., The Fairbanks Co., Binghamton, N. Y.

Morris, Albert W., Cons. Engr., A. W. Morris & Co., Philadelphia, Pa.

Newcomb, Franklin L., Special Apprentice, M. P. Dept. Lake Shore & Mich. Southern Rwy., Cleveland, Ohio

Nygren, Werner, Member of Firm, Nygren, Tenney & Ohmes, Cons. Engrs., New York

Park, Wm. M., Combustion Engr., Green Engineering Co., Chicago, Ill.

Pool, John F., Supt. Amer. Sugar Refining Co. of N. Y., Brooklyn, N. Y.

Rose, Clarence E., Mgr., Merchants Light Co., V.P. & Genl. Mgr., Arkansas Cold Storage Co., Little Rock, Ark.

Sayers, Albert J., Charge of Coal Washery and Mining Depts., Link-Belt Co., Chicago, Ill.

Shaad, George C., Prof. of Elec. Engr., Univ. of Kansas, Lawrence, Kansas.

Shaw, James W., Constr. Dept., Allis-Chalmers Mfg. Co., New York

Shimmin, Robert P., Salesman, Link-Belt Co., Chicago, Ill.

Spear, Grant W., Vice-Pres. and Eastern Mgr., Dearborn Chemical Co., New York

Stone, Louis L., Vice-Pres., Hunt Engrg. Co., Medicine Hat, Alberta, Canada

Talbot, Arthur N., Prof. of Municipal and Sanitary Engrg., University of Illinois, Urbana, Ill.

Thompson, Henry P., Sales Engr., Harrison Safety Boiler Wks., Southern Ohio and Kentucky

Wardenburg, Frederic A., Directing Engr., E. I. duPont de Nemours Powder Co., Wilmington, Del.

Warren, John B., Asst. Genl. Mgr., Philadelphia Steel & Forge Co., New York

Wohra, Har Das, Student, State Univ. of Arkansas, Fayetteville, Ark.

Yates, Preston K., Cons. Engr., 30 Church St., New York

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Beers, Royce L., Junior Fuel Engr., U. S. Bureau of Mines, New York

Best, Jesse L., Ch. Engr., So. Illinois Lt. & Pwr. Co., Hillsboro, Ill.

Bigelow, Pierrepont, Asst. Treas., The Bigelow Co., New Haven, Conn.

Butler, Nathan R., Asst. to Mgr., Jeanesville Iron Wks. Co., Hazleton, Pa.

Casparis, Kenneth E., Asst. Genl. Mgr., The Casparis Stone Co., Columbus, Ohio

Fine, Bernard M., Draftsman, Standard Roller Bearing Co., Philadelphia, Pa.

Fish, Matthew R., Cost Estimator, Amer. Steel & Wire Co., Worcester, Mass.

Gates, Grandon D., Mech. Engr., A. Y. McDonald Mfg. Co., Dubuque, Iowa

Hands, Roland C., Engrg. Dept., Bridgeport Brass Co., Bridgeport, Conn.

Irvin, Richard, Member of Firm, Irvin & Witherow, Engrs., Pittsburgh, Pa.

Osgood, Wentworth H., Ensign, U. S. Navy, care U. S. S. Eagle, New York

Parmely, J. Clyde, Engr., Kewanee Light & Power Co., Kewanee, Ill.

Powers, Alfred R., Prof. of Elec. Engrg., Clarkson College of Tech., Potsdam, N. Y.

Pringle, Nelson S., Engr. of Tests, Autocar Co., Ardmore, Pa.

Rosenbaum, Herbert H., Cons. Engr., Ruebel & Wells Cons. Engrs. Co., St. Louis, Mo.

Shepard, Harold O., Engr., Quigley Furnace & Foundry Co., New York

Thayer, Howard C., Draftsman, M. P. Dept., Interborough Rapid Transit Co., New York.

Wandel, Carleton, Special Apprentice, Pennsylvania Railroad, Altoona, Pa.

FOR CONSIDERATION AS JUNIOR

Anderson, Arvid R., Elec. Engr., Jeffrey Mfg. Co., Columbus, Ohio.

Bowes, Lawrence C., Steam Expert, Inland Steel Co., Indiana Harbor, Ind.

Boyle, James F., With F. B. Gilbreth, Inc., New Haven, Conn.

Burrage, Charles W., Asst. in Mech. Engrg., Mass. Inst. of Tech., Boston, Mass.

Catland, Raymond O., Student, Throop College of Technology, Pasadena, Cal.

de Revere, Arthur W., Sales Engr., Heine Safety Boiler Co., Chicago, Ill.

Goodrich, E. Raymond, Asst. Engr., Wheeler Condenser & Engrg. Co., Carteret, N. J.

McEvoy, Walter C., Engr. for Walter Kidde, Constr. Engr., New York

Meder, Arthur, Asst. Mech. Supt., Individual Drinking Cup Co., New York

Sellman, Nils T., 83 West 115th St., New York

Shandley, James G., Draftsman, M. P. Dept., Interboro R. R., New York

Sheahan, Thomas W., Draftsman, Nelson, Brennan, Peterson, Auto Mfrs., Detroit, Mich.

TRANSFER FROM ASSOCIATE

Keith, Robert R., Asst. Supt., Sheffield Car Co., Three Rivers, Mich.

Lowe, Henry L., Ch. Engr., Natl. Light & Power Co., St. Louis, Mo.

Millspaugh, Wm. H., Pres., Sandusky Fdy. & Mch. Co., Sandusky, Ohio

PROMOTION FROM JUNIOR

PAYSON, T. ELLIOTT, Genl. Supt. and Mech. Engr., The Seneca Falls Mfg. Co., Seneca Falls, N. Y.

PROMOTION FROM ASSOCIATE-MEMBER

AULL, JEROME J., Mech. Engr., The Lunkenheimer Co., Cincinnati, Ohio

SUMMARY

New applications	78
Transfer from Associate	3
Promotion from Associate-Member	1
Promotion from Junior	1
Total	83

REPORT OF THE COMMITTEE ON INCREASE OF MEMBERSHIP

During the fiscal year, ending September 30, 1913, 1046 applications were obtained. This is a gain of 263 applications or about 33⅓ per cent over that of the preceding year.

As a result of this work the Society elected 842 new members, made 87 promotions and had a very substantial list of applications awaiting the action of the Membership Committee.

This increase of members has resulted in increasing the income of the Society for the year by $30,560. The total expense of your Committee for the year was $3,802.55, or about 12½ per cent of the receipts. This is very low when compared with similar figures from other societies. Some organizations report that to get a new member they spend about one-half of the first year's receipts.

Last year the Committee reported that in the ten months of its existence it had secured 783 applications which makes a total of 1815 applications obtained in a little less than two years' time. The number of applications received this year is approximately the same as the total number received in the three years prior to the appointment of this Committee.

As a result of several joint meetings held by the Membership Committee and the Committee on Increase of Membership in the fall of 1912, a new grade of membership was recommended which went into effect at the Spring Meeting held in Baltimore last May. This grade, known as that of Associate Member, aims to provide a place for those engineers over 25 years of age who have really accomplished something in engineering work and are, therefore, entitled to more recognition than the grade of Junior gives. Amendments to the Constitution presented at the 1913 Annual Meeting make 27 years the minimum age for the Associate Member, and for the grade of Member 32 years the minimum, with ten years experience in engineering work.

The year has seen the development of fourteen subcommittees of the Increase of Membership Committee located in important engineering centers of the country. Those thus far appointed and their chairmen, are:

Atlanta, Park A. Dallis	New York, J. A. Kinkead
Boston, A. L. Williston	Philadelphia, T. C. McBride
Buffalo, W. H. Carrier	St. Louis, John Hunter
Chicago, Fay Woodmansee	St. Paul, Max Toltz
Cincinnati, J. T. Faig	San Francisco, Thos. Morrin
Cleveland, R. B. Sheridan	Seattle, R. M. Dyer
Michigan, H. W. Alden	Troy, A. E. Cluett

These sub-committees are composed of from 10 to 25 prominent engineers whose duty it is to canvass carefully the industrial establishments, technical schools and colleges in their vicinity seeking out eligible non-members, and to do all that they can in a proper, dignified manner to induce these engineers to make application for membership.

It is desired to extend the list of sub-committees as rapidly as possible to the end that every important engineering center in the country may be adequately covered.

Another activity of your Committee is the getting into touch with those members whose interest in the Society is waning to such an extent that they contemplate resigning. In many instances these people have renewed their interest and withdrawn their resignations. The Committee has also taken upon itself the work of following up those applicants who fail to qualify after election.

The Committee wishes to call the attention of all our members to the article which has been appearing each month on the first page of The Journal, and will in future appear on the inside front cover. In this space concise information regarding the Society is given which should interest all the members and keep them informed of the objects and privileges of the Society, so that they may be able to advise intelligently inquiring friends and associates as to the procedure necessary to secure membership in the Society.

The curves published herewith show the relative increase of membership for the four national engineering societies since each of them were organized. The vertical lines represent the division of years; the horizontal lines represent the membership in groups of 500 each. Up to 1900 the four societies were all pretty close together, but within the next few years the Electrical Engineers and the Civil Engineers became very active in adding to their membership. Up to 1912 when the Increase of Membership Committee was appointed The American Society of Mechanical Engineers had been making gradual increases in its membership, but it had the smallest number of any of the Societies. Our rate of growth from that time onward has been a little better than any other society.

A study of the geographical distribution of our membership shows that 77 per cent are located in ten states of the Union. There are two states that have but one member, three states that have but two members and five states that have but three members.

Twelve states have less than 90 members each and the remaining fourteen states and territories have less than 25 members each. It is interesting to note that England alone has 62 members; there are only 13 states in the Union that can boast of a greater membership. This indicates that either a large part of our American engineers fail to appreciate the advantages of membership in our Society, or else the advantages of our Society have never been properly brought before them. Your Committee is making every effort to build up the Society by looking up all the engineers in this vast territory who are qualified for membership and the help of every loyal member is needed in the work.

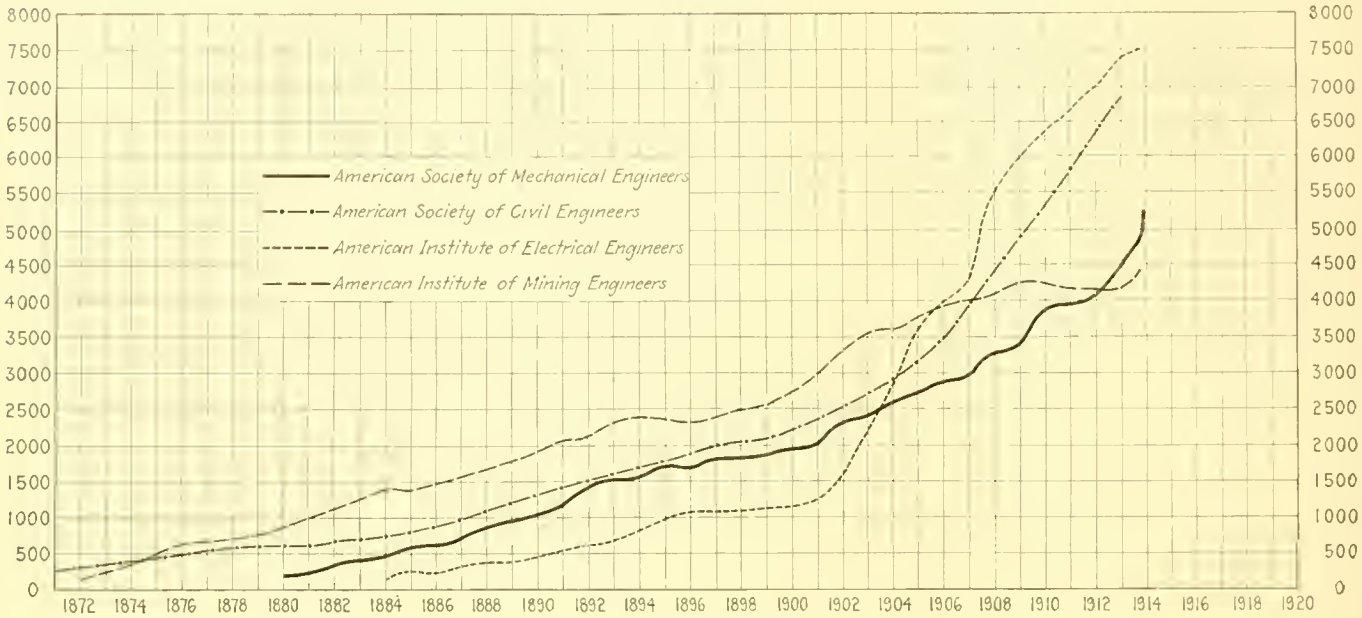
It should be borne in mind that this is a national society and it should make provision to take care of mechanical engineers wherever they may be. By increasing the membership the national society will be made stronger, the benefit to the individual member will be greater and there will be no reason for the existence of the multitude of small and comparatively weak societies which are now springing up all over the country.

Another fact which the Committee believes should have the serious consideration of the Society is that under B-2:

> Applications for membership from Engineers *who are not resident in United States or Canada*, and who may be so situated as not to be personally known to five members of the Society, may be recommended for ballot by five members of the Council, after sufficient evidence has been secured to show that in their opinion the applicant is worthy of admission to the grade which he seeks.

An engineer living in South Dakota where the Society has but one member in the entire state, or from Wyoming where there are but two members in the state, is required to refer to five members of the Society, who not only know him, but have *personal knowledge* of his work. Does it seem at all fair that we accept the application of a Hindoo living in India upon the recommendation of engineers of which the Society has no intimate knowledge? In cases of this kind it is customary to make an investigation through the members of other recognized engineering societies, such as, the British Institution of Mechanical Engineers. The Committee does not criticize the methods employed in dealing with cases which come under B-2, but it believes that we should extend the same or similar privileges to citizens of our own country who reside in states where we have a limited membership.

The Committee has endeavored to build up the Society not only in the industrial centers, but throughout the country wherever engineers are to be found. However, in no case has an invitation to join the Society been extended by the Committee to anyone not suggested by a member. Therefore, the success of the work and the standing of the engineers invited has been dependent upon the response made by the membership. Not more than one-tenth of the members have thus far responded to the efforts of the Committee in this important work, and while much has been accomplished a great deal remains to be done, and it is earnestly hoped that the results already obtained will induce every member to shoulder his share of a work in which all can and should participate.



Respectfully submitted,

I. E. Moultrop, *Chairman*
H. V. O. Coes
F. H. Colvin
J. V. V. Colwell
R. M. Dixon
W. R. Dunn
J. P. Ilsley
E. B. Katte
R. B. Sheridan
H. Struckman

Committee on Increase of Membership

PERSONAL NOTES

Prof. Winslow H. Herschel, formerly assistant professor of mechanical engineering at the University of Maine, has been appointed assistant physicist of the Bureau of Standards in Washington.

Dr. John A. Mathews, manager of the Halcomb Steel Company of Syracuse, N. Y., has been appointed one of a committee of three on the electrometallurgy of iron and steel of the American Electrochemical Society.

Geo. H. Cunningham has resigned as Professor of Mechanical Engineering at the University of Montana, Missoula, Mont., to accept a position in the engineering department of the Anaconda Copper Mining Company, Anaconda, Mont.

The new firm of Norton and Bird, of Chicago, consisting of William J. Norton and Paul P. Bird, has opened its consulting office in the Commercial Bank Building and is prepared to undertake services along the line of rate surveys and schedules, public service properties, etc. Both members of the firm were formerly connected with the Commonwealth Edison Company.

R. G. Williams, formerly assistant research engineer of the Norton Company of Worcester, Mass., has been placed at the head of the company's new department of Safety Engineering. Particular attention is to be given to safety in connection with grinding wheels and the department will keep in touch with the departments of labor, the national council for industrial safety, and the safety engineers of other large corporations. It is expected to draw up specifications for safety devices to be used in connection with grinding wheels.

Dr. Hollis Godfrey has been appointed to the presidency of Drexel Institute of Art, Science and Industry, Philadelphia. Dr. Godfrey has made a study of management methods as applicable to education and is experienced also in the problems of the manufacturer, the merchant and the engineer. Previous to accepting this position he made a study of the needs and opportunities of the institute, through the coöperation of the city administration of Philadelphia, in the furtherance of its plans for the education of city employees. His final report, based upon this survey, has been accepted by the trustees of the institute and his conclusions and recommendations heartily approved.

The committee recently appointed by the Board of Water Commissioners of the City of Hartford to secure the services of experts to pass upon the design and construction of several large dams to be erected in the near future has been able to retain John R. Freeman, Past-President of the Society, to coöperate with Thomas P. Stearns of Boston, and Caleb Mills Saville, chief engineer of the City of Hartford. Mr. Freeman's hydraulic work is known throughout the country, and he has been connected with city supply problems in New York, Boston, Nashua, N. H., Los Angeles, and Baltimore, and with the Isthmian canal lock dams and the water power conservation work of the Canadian Government.

Heinrich J. Freyn, formerly consulting engineer of the gas engineering department of the Allis-Chalmers Manufacturing Company of Milwaukee, Wis., has accepted the position of third vice-president of the H. Koppers Company, of Chicago, builders of by-product coke ovens, gas plants, benzol recovery plants, and by-product recovery gas producer plants, and consulting engineers in matters concerning fuel economy in blast furnaces and steel plants. Mr. Freyn's large experience along these lines and especially in gas engine matters will thus be at the disposition of these industries. He will devote considerable attention to installations of coke oven gas power plants in connection with Koppers cross regenerative by-product coke ovens.

The floating drydock, designed by Wm. T. Donnelly of New York and recently put into commission by the Inter-Island Steam Navigation Company of Honolulu, is capable of docking ships up to and including 4500 tons. It is of the pontoon type, with a length over pontoons of 302 feet, with a width of 76 feet between wings. It has been designed so that the length may be increased to 400 feet, giving it a lifting capacity of 7000 tons. At its present capacity it is composed of nine pontoons 32 feet wide, 100 feet long and 10 feet deep, constructed of wood, and has continuous steel wings 30 feet high by 302 feet long. The pontoons are divided into two water-tight compartments by a center bulkhead, and each compartment is provided with a flood gate valve and a centrifugal pump for sinking and raising the dock.

STEVENS INSTITUTE OF TECHNOLOGY MEETING

Dr. Alex. C. Humphreys, President of Stevens Institute of Technology and Past-President of the Society, John W. Lieb, Jr., manager of the New York Edison Company, and James E. Sague, a member of the New York Public Service Commission, both members of the Society, and other prominent engineers will speak at the Technology Meeting, on January 9, at 3 o'clock in the Stevens Institute of Technology. The topic of the meeting will be Public Service Corporations and their Relations to the Public, and the members of the Society are invited to attend.

DEPARTMENT OF ENGINEERING AT THE JOHNS HOPKINS UNIVERSITY

The Johns Hopkins University has established a department of engineering for which extensive laboratories and class room buildings are now under construction, made possible by large appropriations from the State of Maryland, which, however, exercises no control over the university. The new buildings have complete facilities for graduate and research work as well as for the undergraduate courses. Courses in Civil, Electrical and Mechanical Engineering have been established. Professor Carl C. Thomas, formerly head of the department of mechanical engineering at the University of Wisconsin, is the director of the new course in mechanical engineering. The department of engineering will not include machine shops, except as used for machine tools in laboratory equipment. Each undergraduate student will be required to spend four months in a commercial shop or drawing office during his course in addition to some field work in surveying during the summer vacation. The Johns Hopkins University has long been known for its research work and much of the effort of the engineering department will be concentrated upon engineering research. Fifty-five undergraduates and fifteen graduate students have entered the department this fall.

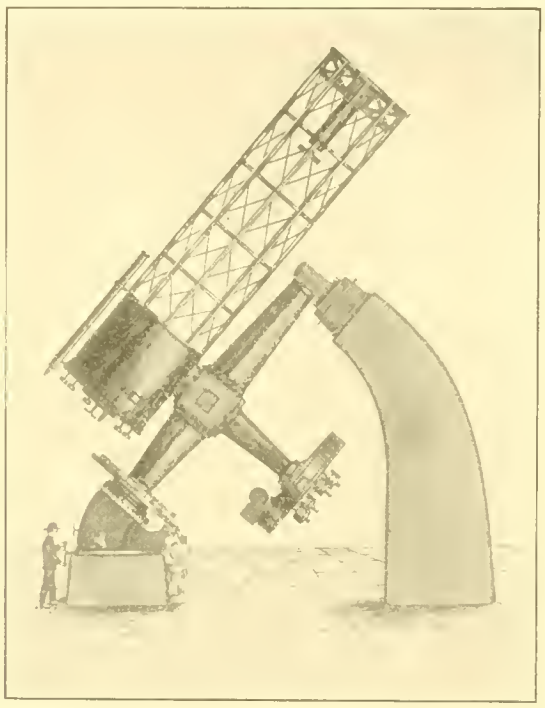
THE LARGEST REFLECTING TELESCOPE

The 60-inch reflecting telescope at the Mount Wilson Observatory, Cal., is at the present time the largest in existence, and its revelations have greatly advanced the knowledge of the stellar universe. There is now to be constructed

for the Dominion Observatory at Ottawa, Canada, a 72-inch reflector, which will be 50 per cent more powerful than this. The work of construction will be directed by three of the members of the Society who have done so much for the practical advancement of the science of astronomy, Worcester R. Warner and Ambrose Swasey, Past-Presidents, and John A. Brashear, Honorary Member. The contract for the mounting has been awarded to the Warner & Swasey Company of Cleveland, which also built the mountings for the Lick telescope in 1887, with its 36-inch object glass, and the Yerkes telescope in 1893, 40 inches in diameter. The optical parts will be constructed by the J. A. Brashear Company, Ltd., of Pittsburgh.

Mr. Warner has supplied the following information:

The Canadian instrument will, when completed, weigh fully 50 tons and will rest upon massive piers of concrete. The tube which will be 30 feet long and 7 feet in diameter,



will weigh 10 tons. At the lower end of the tube will be located the principal speculum composed of a disk of glass 73 inches in diameter, 10 inches in thickness, and weighing approximately 2 tons. When used as a Cassegrainian instrument a secondary convex reflector, 19 inches in diameter, will be placed near the end of the tube for reflecting rays back through a hole in the speculum, 10 inches in diameter, to the great spectroscope attached to the lower end of the tube. As a Newtonian instrument, a flat mirror will be provided for reflecting the cone of rays at right angles into the photographic apparatus at the upper edge of the tube. As a direct vision instrument, both secondary mirrors will be removed and appliances for visual, photographic and spectroscopic work will be attached at the prime focus. The tube and the declination and polar axes, with their attachments, weigh 35 tons, and so nicely is each part balanced and adjusted that the powerful driving clock will revolve this immense weight with such accuracy and uniformity that the spider line in the eyepiece of the pointing telescope, attached to the great tube, can be kept exactly on the center of the star in observation.

For visual and micrometric instruments the great refracting telescopes, such as the Lick and Yerkes, will maintain their supremacy, while for astronomical photography the great reflecting telescopes are far superior. A number of reflecting telescopes of large sizes are in contemplation in various parts of the world at the present time, and it is very probable that at an early date news will be received of projects to build other large instruments of this kind.

COLLEGE REUNIONS

A number of colleges held their alumni reunions on the evening of Friday, December 5, in conjunction with the Annual Meeting. A brief account of the various events is given herewith:

STEVENS INSTITUTE OF TECHNOLOGY

The Alumni Association of Stevens Institute of Technology gave a theater party at the New Amsterdam Theater on their Annual Stevens Night. The house was decorated with the college colors and was filled with alumni and undergraduates and their friends. Calvin W. Rice, Dr. W. F. M. Goss, Dr. Alex. C. Humphreys, and James Hartness were guests of the association. A supper and dance at the Hotel Astor followed the performance.

WORCESTER POLYTECHNIC INSTITUTE

The alumni of Worcester Polytechnic Institute gave a dinner in the College Room of the Hotel Astor in honor of the institute's new president, Ira N. Hollis, formerly professor of mechanical engineering at Harvard. About sixty-five alumni were present and a most enthusiastic meeting followed the dinner. The speakers of the evening were Professor Hollis and Mr. Charles G. Washburn, president of the board of trustees.

POLYTECHNIC INSTITUTE OF BROOKLYN

The annual reunion of the alumni of the Polytechnic Institute of Brooklyn was held in the rooms of the Society. Short addresses were made by Dr. Goss and Mr. F. W. Atkinson, president of the Institute, after which a reception was held.

YALE UNIVERSITY

Twenty-nine alumni attended the Engineering Alumni Dinner of Yale University given at the Yale Club. Prof. L. P. Breckenridge presided, and the affair was so successful that a committee was appointed to consider the formation of a Yale Engineering Society, with an annual reunion of this same character as one of the prominent features.

KENTUCKY STATE UNIVERSITY

The Kentucky State University Club of New York held an informal dinner and meeting at Keene's Chop House. After dinner the affairs of the university were brought up for discussion and the work of the New York Club now under way was fully outlined.

BROWN UNIVERSITY

The engineering alumni of Brown University held their reunion dinner at the Brown Club.

CORNELL UNIVERSITY

The Cornell University reunion dinner was held at the Cornell University Club with an attendance of fifty-four. Addresses were made by members of the club.

REPORT OF THE COMMITTEE OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS ON STANDARDIZATION OF FLANGES[1]

THE Committee on Standardization of Flanges of The American Society of Mechanical Engineers, has presented the following report on a standard for pipe flanges, fittings, and bolting for the same, together with a recommendation in regard to minimum thickness of wall in cast-iron pipe. The committee recommends that this new standard shall be known as the American Standard.

This new standard was arrived at after a long series of conferences with the Committee of Manufacturers on Standardization of Fittings and Valves and is a compromise, consistent with good engineering practice, between the 1912 U. S. Standard heretofore recommended by the Society's committee (published in The Journal for February 1912) and the Manufacturers' Standard adopted in 1912.

In addition to the adoption of the compromise standard, the committee, in conjunction with the Manufacturers' Committee, have extended the standard weight or low-pressure sizes from 30 in. to 100 in., in order to provide for the large sizes now called for in connection with steam-turbine installations, etc., and have also extended the extra heavy or high-pressure sizes from 24 in. to 48 in., in order to take care of high-pressure water mains.

The committee believes that the compromise standard here presented combines all the advantages of the 1912 U. S. Standard with the best points in the Manufacturers' Standard, and, owing to the extension from 30 in. to 100 in. in the low-pressure and from 24 in. to 48 in. in the high-pressure sizes, gives much more consistent dimensions and stresses in the larger sizes.

FLANGES AND BOLTS

General. Generally speaking, in so far as flanges and bolting are concerned, the 1912 U. S. Standard 125-lb. schedule, sizes 1 in. to 30 in. inclusive, remains almost unchanged. Nearly all of the alterations to the flanges and the bolting of the 250-lb. 1912 U. S. Standard, 1 in. to 24 in. inclusive, are the result of compromises with the Manufacturers' Standard, and when taken in connection with new additional sizes, 26 in. to 48 in. inclusive, form a more regular design than would have occurred had the manufacturers' sizes been accepted without compromise.

Fig. 1 contains comparative bolt stress curves of 125-lb. sizes, 1 in. to 30 in., and 250-lb., 1 in. to 24 in., for the Manufacturers' Standard of October 1912, the 1912 U. S. Standard, and the proposed American Standard. It will be plainly seen from the more regular form of curve that the new American Standard is better than either of the other two. The bolt stress curve at the 4-in., 22-in. and 24-in. sizes of the 125-lb. standard have been made less abrupt. The one for the 250-lb. standard at the 14-in., 16-in., 18-in., 20-in., 22-in. and 24-in. sizes shows the compromise more in favor of the 1912 U. S. Standard than that of the Manufacturers', and at the same time, as before stated, connecting better with the curve for new additional sizes.

Bolt Circles. The only 1912 U. S. bolt circle changed was on the 250-lb. 10-in. size. This was changed from 15¾ in. to 15¼ in. in diameter, as a result of a conference with the Manufacturers' Committee. The Manufacturers' Committee adopted the 1912 U. S. Standard bolt circles for the 250-lb. 14-in., 15-in., 18-in., 20-in., 22-in. and 24-in. pipe sizes, changing in each case their October 1912 Standard to do so.

Flange Diameters. Regarding flange diameters, the 250-lb. 9-in. and 10-in. sizes were changed to suit the Manufacturers' schedule. Sizes 12-in., 14-in., 15-in., 16-in., 18-in. and 20-in. were also changed and form a fair compromise between the 1912 U. S. and the Manufacturers' Standards. The American Standard flange diameters for the 22-in. and 24-in. pipe sizes are identical with those of the 1912 U. S. Standard, the Manufacturers' Committee changing their own standard to adopt same. Nearly all of these changes were made to suit the changed diameters of bolts before mentioned.

Flange Cross Sections. Every effort has been made to grade all sizes as uniformly as was found consistent with sudden changes in the number of bolts necessary to allow of flanges turning on 90-deg. angles.

Bolt Diameters. 125-Lb. Working Pressure. Changes which were made to the 1912 U. S. 125-lb. Standard are as follows: the ¾ in. diameter of bolt for the 4-in. size was made ⅝ in., making it conform to the Manufacturers' Standard. The bolts on the 22-in. and 24-in. sizes were increased from 1⅛ in. to 1¼ in. diameter (American Standard). These changes were made to improve the conformity of the stress curve.

250-Lb. Working Pressure. The changes made to the 1912 U. S. 250-lb. Standard are shown on Fig. 1, as follows: The 1¼ in. diameter of bolt for the

[1] Here published in abstract, with an abstract of the discussion upon the report given at the Annual Meeting, 1913. There will be opportunity for further discussion upon it at the next Spring Meeting. Complete copies of the report may be purchased of the Society. Price to members, 20 cents per copy; to non-members, 40 cents per copy.

14-in. size is now $1\frac{1}{8}$ in. The $1\frac{3}{8}$ in. for the 16-in. and 18-in. sizes is changed to $1\frac{1}{4}$ in. The $1\frac{1}{2}$ in. diameter for the 20-in. size is made $1\frac{3}{8}$ in. In meeting the requirements of the American Standard, the Manufacturers' Committee changed their bolt diameters for the 12-in., 14-in., 15-in., 16-in., 18-in., 20-in., 22-in. and 24-in. pipe sizes.

Changes in Number of Bolts. The number of bolts on the 22-in. and 24-in. sizes was changed from 28, in the 1912 U. S. and the Manufacturers' Standards, to 24, to agree with the American Standard.

FLANGED FITTINGS

1 In. to 30 In. in Diameter for 125 Lb. and 1 In. to 24 In. for 250 Lb. Working Pressure per Sq. In.

The new schedule for flanged fittings is made up of dimensions, many of which are common to both the 1912 U. S. Standard and the Manufacturers' Standard of October 1, 1912. The remaining dimensions were suggested by the Manufacturers' Committee as changes to their own standard of October 1912, in an attempt to approach the 1912 U. S. Standard as closely as possible, and at the same time to admit of making use of many of their present patterns. As the suggestions of the Manufacturers did not involve any question of strength, and as the variations from the 1912 U. S. Standard were, for the most part, slight (as shown by comparative curves of face to face dimensions, Figs. 2 and 3), it was considered advisable to adopt these suggestions.

Additional Sizes. Additional sizes of 125-lb. flanged fittings, 32 in. to 100 in. inclusive, and 250-lb., 26 in. to 48 in. inclusive, were worked up in schedule form by the Manufacturers' Committee and presented for the consideration of the A.S.M.E. Committee. The A.S.M.E. additional flange and bolting sizes were all incorporated in the designs for these fittings. Curves of center to face dimensions were then worked up in connection with the present standard sizes and were found by the A.S.M.E. Committee to form a complete and uniform design.

Interchangeability. On all reducing tees and crosses from 1 in. to 9 in. inclusive, the center to face dimension of the various outlets is the same on fittings of the same size run.

Example: All center to face dimensions of a 5-in. by 5-in. by 1-in. tee are the same as a 5-in. by 5-in. by 5-in. tee and are interchangeable with any combination of 5-in. cross.

Cast-Iron Pipe Wall Thicknesses. In connection with the flange and fitting schedules, it was considered desirable to determine a minimum for pipe wall thicknesses, for 125-lb. sizes, 1 in. to 100 in., and 250 lb. 1 in. to 48 in. Accordingly, curves were plotted from a formula adopted July 18, 1894, by the Committees of the A.S.M.E. and the Master Steam and Hot Water Fitters Association for 75-lb. and 200-lb. flange schedule. The thicknesses derived from this formula were found to be somewhat thinner than those in use by the manufacturers. The formula was then increased by a constant of 1.2 and curves plotted, which was embodied in the new standard and values for which are given in Tables 1 and 2. The 125-lb. curve of the Manufacturers' sizes coincides with that of the American Standard for all standard sizes, except the 30-in., which, together with additional sizes 32 in. to 48 in., call for a gradual increase in thicknesses. The 250-lb. curve of the Manufacturers closely follows that of the American Standard.

Pipe Wall Stresses. The stresses in pipe walls given in the new American Standard schedules, Tables 1 and 2 (125-lb. and 250-lb.), are calculated by the following formula in customary use for low pressures:

$$S = \frac{D \times p}{2 \times t}$$

where

D = inside diameter of pipe t = thickness of pipe p = working pressure per sq. in.,

or more simply

$$S = \frac{r \times p}{t}$$

where

r = inside radius of pipe

The highest stress was found to be 2000 lb. per sq. in. on the 250-lb. 46-in. and 48-in. pipe walls, giving a factor of safety of about 10.

EXPLANATORY NOTES

a Standard and Extra Heavy Reducing Elbows carry same dimensions center to face as regular Elbows of largest straight size.

b Standard and Extra Heavy Tees, Crosses and Laterals, reducing on run only, carry same dimensions face to face as largest straight size.

c If Flanged Fittings for lower working pressure than 125 lb. are made, they shall conform in all dimensions except thickness of shell, to this standard and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be standard dimensions.

d Where long radius fittings are specified, it has reference only to Elbows which are made in two center to face dimensions and to be known as Elbows and Long Radius Elbows, the latter being used only when so specified.

e All standard weight fittings must be guaranteed for 125-lb. working pressure and extra heavy fittings for 250-lb. working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.

f All extra heavy fittings and flanges to have a raised surface of $\frac{1}{16}$ in. high inside of bolt holes for gaskets.

Standard weight fittings and flanges to be plain faced.

Bolt holes to be $\frac{1}{8}$ in. larger in diameter than bolts.

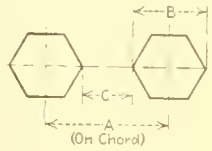
Bolt holes to straddle center line.

g Size of all fittings scheduled indicates inside diameter of ports, except for extra heavy fittings 14 in. and larger when the port diameter is $\frac{3}{4}$ in. smaller than nominal size.

h The face to face dimension of reducers, either straight

TABLE 1 SCHEDULE OF STANDARD PIPE FLANGES FROM 1 IN. TO 100 IN. FOR 125-LB. WORKING PRESSURE

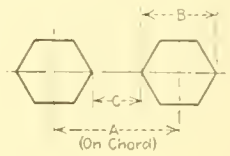
Diameter of Pipe	Thickness of Pipe $\left[\frac{P+100}{4\times S}D+0.333\left(1-\frac{D}{100}\right)\right]^{1.2}$ $(S=1800)$	Minimum Thickness (Fractions of an in.)	Stress on Pipe per Sq. In.	Diameter of Flange	Thickness of Flange	Width of Flange Face	Diameter of Bolt Circle	No. of Bolts	Diameter of Bolts	Effective Area	Stress per Sq. In. on Bolt Metal	Diameter of Bolt Holes	A	B	C
1	0.43	7/16	143	4	7/16	1 1/2	3	4	7/16	0.093	264	9/16	2.12	0.91	1.21
1 1/4	0.44	7/16	178	4 1/2	1/2	1 5/8	3 3/8	4	7/16	0.093	412	9/16	2.38	0.91	1.47
1 1/2	0.45	7/16	214	5	9/16	1 3/4	3 7/8	4	1/2	0.126	438	5/8	2.73	1.00	1.73
2	0.46	7/16	286	6	5/8	2	4 3/4	4	5/8	0.202	486	3/4	3.35	1.21	2.14
2 1/2	0.48	7/16	357	7	11/16	2 1/4	5 1/2	4	5/8	0.202	750	3/4	3.88	1.21	2.67
3	0.50	7/16	428	7 1/2	3/4	2 1/4	6	4	5/8	0.202	1093	3/4	4.23	1.21	3.02
3 1/2	0.52	7/16	500	8 1/2	13/16	2 1/2	7	4	5/8	0.202	1488	3/4	4.94	1.21	3.73
4	0.53	1/2	500	9	15/16	2 1/2	7 1/2	8	5/8	0.202	972	3/4	2.87	1.21	1.56
4 1/2	0.55	1/2	562	9 1/4	15/16	2 5/8	7 3/4	8	3/4	0.302	823	7/8	2.96	1.44	1.52
5	0.56	1/2	625	10	15/16	2 1/2	8 1/2	8	3/4	0.302	1016	7/8	3.25	1.44	1.81
6	0.60	9/16	667	11	1	2 1/2	9 1/2	8	3/4	0.302	1463	7/8	3.63	1.44	2.19
7	0.63	5/8	700	12 1/2	1 1/16	2 3/4	10 3/4	8	3/4	0.302	1991	7/8	4.11	1.44	2.67
8	0.66	5/8	800	13 1/2	1 1/8	2 3/4	11 3/4	8	3/4	0.302	2600	7/8	4.50	1.44	3.06
9	0.70	11/16	818	15	1 1/8	3	13 1/4	12	3/4	0.302	2194	7/8	3.43	1.44	1.99
10	0.73	3/4	833	16	1 3/16	3	14 1/4	12	7/8	0.420	1948	1	3.69	1.66	2.03
12	0.80	13/16	923	19	1 1/4	3 1/2	17	12	7/8	0.420	2805	1	4.40	1.66	2.74
14	0.86	7/8	1000	21	1 3/8	3 1/2	18 3/4	12	1	0.550	2915	1 1/8	4.86	1.88	2.98
15	0.90	7/8	1072	22 1/4	1 3/8	3 5/8	20	16	1	0.550	2510	1 1/8	3.90	1.88	2.02
16	0.93	1	1000	23 1/2	1 7/16	3 3/4	21 1/4	16	1	0.550	2856	1 1/8	4.14	1.88	2.26
18	1.00	1 1/16	1059	25	1 9/16	3 1/2	22 3/4	16	1 1/8	0.694	2865	1 1/4	4.44	2.09	2.35
20	1.07	1 1/8	1111	27 1/2	1 11/16	3 3/4	25	20	1 1/8	0.694	2829	1 1/4	3.91	2.09	1.82
22	1.13	1 3/16	1158	29 1/2	1 13/16	3 3/4	27 1/4	20	1 1/4	0.893	2660	1 3/8	4.26	2.31	1.95
24	1.20	1 1/4	1200	32	1 5/8	4	29 1/2	20	1 1/4	0.893	3466	1 3/8	4.62	2.31	2.31
26	1.27	1 5/16	1238	34 1/4	2	4 1/8	31 3/4	24	1 1/4	0.893	3096	1 3/8	4.14	2.31	1.83
28	1.33	1 3/8	1273	36 1/2	2 1/16	4 1/4	34	28	1 1/4	0.893	3078	1 3/8	3.81	2.31	1.50
30	1.40	1 7/16	1304	38 3/4	2 1/8	4 3/8	36	28	1 3/8	1.057	2985	1 1/2	4.03	2.53	1.50
32	1.47	1 1/2	1333	41 3/4	2 1/4	4 5/8	38 1/2	28	1 1/2	1.294	2775	1 5/8	4.31	2.75	1.56
34	1.54	1 9/16	1360	43 3/4	2 5/16	4 7/8	40 1/2	32	1 1/2	1.294	2741	1 5/8	3.97	2.75	1.22
36	1.60	1 5/8	1385	46	2 3/8	5	42 3/4	32	1 1/2	1.294	3073	1 5/8	4.19	2.75	1.44
38	1.67	1 11/16	1407	48 3/4	2 3/8	5 3/8	45 1/4	32	1 5/8	1.515	2924	1 3/4	4.43	2.96	1.47
40	1.73	1 3/4	1428	50 3/4	2 1/2	5 3/8	47 1/4	36	1 5/8	1.515	2880	1 3/4	4.11	2.96	1.15
42	1.82	1 13/16	1448	53	2 5/8	5 1/2	49 1/2	36	1 5/8	1.515	3175	1 3/4	4.31	2.96	1.35
44	1.87	1 7/8	1467	55 1/4	2 5/8	5 5/8	51 3/4	40	1 5/8	1.515	3136	1 3/4	4.06	2.96	1.10
46	1.94	1 15/16	1484	57 1/4	2 11/16	5 5/8	53 3/4	40	1 5/8	1.515	3428	1 3/4	4.22	2.96	1.26
48	2.00	2	1500	59 1/2	2 3/4	5 3/4	56	44	1 5/8	1.515	3393	1 3/4	3.98	2.96	1.02
50	2.07	2 1/16	1515	61 3/4	2 3/4	5 7/8	58 1/4	44	1 3/4	1.746	3195	1 7/8	4.14	3.19	0.95
52	2.14	2 1/8	1530	64	2 7/8	6	60 1/2	44	1 3/4	1.746	3456	1 7/8	4.30	3.19	1.11
54	2.20	2 3/16	1543	66 1/4	3	6 1/8	62 3/4	44	1 3/4	1.746	3726	1 7/8	4.45	3.19	1.26
56	2.27	2 1/4	1555	68 3/4	3	6 3/8	65	48	1 3/4	1.746	3674	1 7/8	4.26	3.19	1.07
58	2.34	2 5/16	1567	71	3 1/8	6 1/2	67 1/4	48	1 3/4	1.746	3941	1 7/8	4.40	3.19	1.21
60	2.41	2 7/16	1538	73	3 1/8	6 1/2	69 1/4	52	1 3/4	1.746	3892	1 7/8	4.19	3.19	1.00
62	2.47	2 1/2	1550	75 3/4	3 1/4	6 7/8	71 3/4	52	1 7/8	2.051	3538	2	4.34	3.41	0.93
64	2.54	2 9/16	1561	78	3 1/4	7	74	52	1 7/8	2.051	3770	2	4.48	3.41	1.07
66	2.61	2 5/8	1572	80	3 3/8	7	76	52	1 7/8	2.051	4010	2	4.60	3.41	1.19
68	2.68	2 11/16	1582	82 1/4	3 3/8	7 1/8	78 1/4	56	1 7/8	2.051	3952	2	4.38	3.41	0.97
70	2.74	2 3/4	1591	84 1/2	3 1/2	7 1/4	80 1/2	56	1 7/8	2.051	4188	2	4.51	3.41	1.10
72	2.81	2 13/16	1600	86 1/2	3 1/2	7 1/4	82 1/2	60	1 7/8	2.051	4136	2	4.33	3.41	0.92
74	2.88	2 7/8	1609	88 1/2	3 5/8	7 1/4	84 1/2	60	1 7/8	2.051	4368	2	4.44	3.41	1.03
76	2.94	2 15/16	1617	90 3/4	3 5/8	7 3/8	86 1/2	60	1 7/8	2.051	4608	2	4.54	3.41	1.13
78	3.01	3	1625	93	3 3/4	7 1/2	88 3/4	60	2	2.302	4325	2 1/8	4.66	3.63	1.03
80	3.08	3 1/16	1633	95 1/4	3 3/4	7 5/8	91	60	2	2.302	4549	2 1/8	4.78	3.63	1.15
82	3.15	3 1/8	1640	97 1/2	3 7/8	7 3/4	93 1/4	60	2	2.302	4779	2 1/8	4.90	3.63	1.27
84	3.21	3 3/16	1647	99 3/4	3 7/8	7 7/8	95 1/2	64	2	2.302	4702	2 1/8	4.68	3.63	1.05
86	3.28	3 1/4	1653	102	4	8	97 3/4	64	2	2.302	4928	2 1/8	4.79	3.63	1.16
88	3.35	3 5/16	1660	104 1/4	4	8 1/8	100	68	2	2.302	4857	2 1/8	4.60	3.63	0.97
90	3.41	3 3/8	1667	106 1/2	4 1/8	8 1/4	102 1/4	68	2 1/8	2.648	4416	2 1/4	4.71	3.83	0.88
92	3.48	3 1/2	1643	108 3/4	4 1/8	8 3/8	104 1/2	68	2 1/8	2.648	4615	2 1/4	4.81	3.83	0.98
94	3.55	3 9/16	1649	111	4 1/4	8 1/2	106 1/4	68	2 1/4	2.648	4817	2 1/4	4.89	3.83	1.06
96	3.62	3 5/8	1655	113 1/4	4 1/4	8 5/8	108 1/2	68	2 1/4	3.023	4401	2 3/8	4.99	4.06	0.93
98	3.68	3 11/16	1661	115 1/2	4 3/8	8 3/4	110 3/4	68	2 1/4	3.023	4587	2 3/8	5.09	4.06	1.03
100	3.75	3 3/4	1667	117 3/4	4 3/8	8 7/8	113	68	2 1/4	3.023	4776	2 3/8	5.20	4.06	1.14



NOTES:—Bolt holes should straddle center lines. Flanges should be plain faced.
Square head bolts with hexagonal nuts are recommended. For bolts 1 1/8 in. diameter and larger stud with a nut at each end is satisfactory.
Hexagonal nuts for pipe sizes 1 in. to 46 in. can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 48 in. to 100 in. can be conveniently pulled up with box or socket wrenches.
RULES approximately followed in compiling above data:

Bolt circle $= 1.10\,D + 3$
Flange thickness $= 0.0315\,D + 1.25$
D = inside diameter of pipe

TABLE 2 SCHEDULE OF EXTRA HEAVY PIPE FLANGES FROM 1 IN. TO 48 IN. FOR 250-LB. WORKING PRESSURE

Diameter of Pipe	Thickness of Pipe $\left[\frac{P+100}{1\times S}D+0.333\left(1+\frac{D}{100}\right)\right]^{1.2}$ (S = 1800)	Minimum Thickness (Fractions of an In.)	Stress on Pipe per Sq. In.	Diameter of Flange	Thickness of Flange	Width of Flange Face	Diameter of Bolt Circle	No. of Bolts	Diameter of Bolts	Effective Area	Stress per Sq. In. on Bolt Metal	Diameter of Bolt Holes	A	B	C
															
1	0.45	$\frac{1}{2}$	250	$4\frac{1}{2}$	$\frac{11}{16}$	$1\frac{3}{4}$	$3\frac{1}{4}$	4	$\frac{1}{2}$	0.126	389	$\frac{5}{8}$	2.29	1.00	1.29
$1\frac{1}{4}$	0.47	$\frac{1}{2}$	312	5	$\frac{3}{4}$	$1\frac{7}{8}$	$3\frac{3}{4}$	4	$\frac{1}{2}$	0.126	609	$\frac{5}{8}$	2.65	1.00	1.65
$1\frac{1}{2}$	0.49	$\frac{1}{2}$	375	6	$\frac{13}{16}$	$2\frac{1}{4}$	$4\frac{1}{2}$	4	$\frac{5}{8}$	0.202	547	$\frac{3}{4}$	3.17	1.21	1.96
2	0.51	$\frac{1}{2}$	500	$6\frac{1}{2}$	$\frac{7}{8}$	$2\frac{1}{4}$	5	4	$\frac{5}{8}$	0.202	972	$\frac{3}{4}$	3.53	1.21	2.32
$2\frac{1}{2}$	0.53	$\frac{9}{16}$	555	$7\frac{1}{2}$	1	$2\frac{1}{2}$	$5\frac{7}{8}$	4	$\frac{3}{4}$	0.302	1016	$\frac{7}{8}$	4.15	1.44	2.71
3	0.56	$\frac{9}{16}$	667	$8\frac{1}{4}$	$1\frac{1}{8}$	$2\frac{5}{8}$	$6\frac{5}{8}$	8	$\frac{3}{4}$	0.302	731	$\frac{7}{8}$	2.53	1.44	1.09
$3\frac{1}{2}$	0.59	$\frac{9}{16}$	778	9	$1\frac{3}{16}$	$2\frac{3}{4}$	$7\frac{1}{4}$	8	$\frac{3}{4}$	0.302	995	$\frac{7}{8}$	2.77	1.44	1.33
4	0.61	$\frac{5}{8}$	800	10	$1\frac{1}{4}$	3	$7\frac{7}{8}$	8	$\frac{3}{4}$	0.302	1300	$\frac{7}{8}$	3.01	1.44	1.57
$4\frac{1}{2}$	0.64	$\frac{5}{8}$	900	$10\frac{1}{2}$	$1\frac{5}{16}$	3	$8\frac{1}{2}$	8	$\frac{3}{4}$	0.302	1646	$\frac{7}{8}$	3.25	1.44	1.81
5	0.67	$\frac{11}{16}$	909	11	$1\frac{3}{8}$	3	$9\frac{1}{4}$	8	$\frac{3}{4}$	0.302	2032	$\frac{7}{8}$	3.53	1.44	2.09
6	0.72	$\frac{3}{4}$	1000	$12\frac{1}{2}$	$1\frac{7}{16}$	$3\frac{1}{4}$	$10\frac{5}{8}$	12	$\frac{3}{4}$	0.302	1950	$\frac{7}{8}$	2.75	1.44	1.31
7	0.78	$\frac{13}{16}$	1077	14	$1\frac{1}{2}$	$3\frac{1}{2}$	$11\frac{7}{8}$	12	$\frac{7}{8}$	0.420	1909	1	3.07	1.66	1.41
8	0.83	$\frac{13}{16}$	1230	15	$1\frac{5}{8}$	$3\frac{1}{2}$	13	12	$\frac{7}{8}$	0.420	2493	1	3.36	1.66	1.70
9	0.89	$\frac{7}{8}$	1285	$16\frac{1}{4}$	$1\frac{3}{4}$	$3\frac{5}{8}$	14	12	1	0.550	2410	$1\frac{1}{8}$	3.62	1.88	1.74
10	0.94	$\frac{15}{16}$	1333	$17\frac{1}{2}$	$1\frac{7}{8}$	$3\frac{3}{4}$	$15\frac{1}{4}$	16	1	0.550	2231	$1\frac{1}{8}$	2.97	1.88	1.09
12	1.05	1	1500	$20\frac{1}{2}$	2	$4\frac{1}{4}$	$17\frac{3}{4}$	16	$1\frac{1}{8}$	0.694	2546	$1\frac{1}{4}$	3.46	2.09	1.37
14	1.16	$1\frac{1}{8}$	1555	23	$2\frac{1}{8}$	$4\frac{1}{2}$	$20\frac{1}{4}$	20	$1\frac{1}{8}$	0.694	2773	$1\frac{1}{4}$	3.17	2.09	1.08
15	1.21	$1\frac{3}{16}$	1579	$24\frac{1}{2}$	$2\frac{3}{16}$	$4\frac{3}{4}$	$21\frac{1}{2}$	20	$1\frac{1}{4}$	0.893	2473	$1\frac{3}{8}$	3.36	2.31	1.05
16	1.27	$1\frac{1}{4}$	1600	$25\frac{1}{2}$	$2\frac{1}{4}$	$4\frac{3}{4}$	$22\frac{1}{2}$	20	$1\frac{1}{4}$	0.893	2814	$1\frac{3}{8}$	3.52	2.31	1.21
18	1.37	$1\frac{3}{8}$	1636	28	$2\frac{3}{8}$	5	$24\frac{3}{4}$	24	$1\frac{1}{4}$	0.893	2968	$1\frac{3}{8}$	3.23	2.31	0.92
20	1.48	$1\frac{1}{2}$	1666	$30\frac{1}{2}$	$2\frac{1}{2}$	$5\frac{1}{4}$	27	24	$1\frac{3}{8}$	1.057	3096	$1\frac{1}{2}$	3.52	2.53	0.99
22	1.59	$1\frac{9}{16}$	1760	33	$2\frac{5}{8}$	$5\frac{1}{4}$	$29\frac{1}{4}$	24	$1\frac{1}{2}$	1.295	3058	$1\frac{5}{8}$	3.81	2.75	1.06
24	1.70	$1\frac{5}{8}$	1846	36	$2\frac{3}{4}$	$5\frac{3}{4}$	32	24	$1\frac{5}{8}$	1.515	3110	$1\frac{3}{4}$	4.18	2.96	1.22
26	1.81	$1\frac{13}{16}$	1793	$38\frac{1}{4}$	$2\frac{13}{16}$	$6\frac{1}{8}$	$34\frac{1}{2}$	28	$1\frac{5}{8}$	1.515	3126	$1\frac{3}{4}$	3.86	2.96	0.90
28	1.91	$1\frac{7}{8}$	1866	$40\frac{3}{4}$	$2\frac{15}{16}$	$6\frac{3}{8}$	37	28	$1\frac{5}{8}$	1.515	3629	$1\frac{3}{4}$	4.14	2.96	1.18
30	2.02	2	1875	43	3	$6\frac{1}{2}$	$39\frac{1}{4}$	28	$1\frac{3}{4}$	1.746	3615	$1\frac{7}{8}$	4.38	3.19	1.19
32	2.13	$2\frac{1}{8}$	1882	$45\frac{1}{4}$	$3\frac{1}{8}$	$6\frac{5}{8}$	$41\frac{1}{2}$	28	$1\frac{7}{8}$	2.051	3501	2	4.64	3.41	1.26
34	2.24	$2\frac{1}{4}$	1889	$47\frac{1}{2}$	$3\frac{1}{4}$	$6\frac{3}{4}$	$43\frac{1}{2}$	28	$1\frac{7}{8}$	2.051	3952	2	4.87	3.41	1.46
36	2.35	$2\frac{3}{8}$	1894	50	$3\frac{3}{8}$	7	46	32	$1\frac{7}{8}$	2.051	3877	2	4.50	3.41	1.09
38	2.46	$2\frac{7}{16}$	1948	$52\frac{1}{4}$	$3\frac{7}{16}$	$7\frac{1}{8}$	48	32	$1\frac{7}{8}$	2.051	4320	2	4.70	3.41	1.29
40	2.56	$2\frac{9}{16}$	1953	$54\frac{1}{2}$	$3\frac{9}{16}$	$7\frac{1}{4}$	$50\frac{1}{4}$	36	$1\frac{7}{8}$	2.051	4255	2	4.38	3.41	0.97
42	2.67	$2\frac{11}{16}$	1953	57	$3\frac{11}{16}$	$7\frac{1}{2}$	$52\frac{3}{4}$	36	$1\frac{7}{8}$	2.051	4691	2	4.59	3.41	1.18
44	2.78	$2\frac{13}{16}$	1955	$59\frac{1}{4}$	$3\frac{3}{4}$	$7\frac{5}{8}$	55	36	2	2.302	4587	$2\frac{1}{8}$	4.79	3.63	1.16
46	2.89	$2\frac{7}{8}$	2000	$61\frac{1}{2}$	$3\frac{7}{8}$	$7\frac{3}{4}$	$57\frac{1}{4}$	40	2	2.302	4512	$2\frac{1}{8}$	4.49	3.63	0.86
48	3.00	3	2000	65	4	$8\frac{1}{2}$	$60\frac{3}{4}$	40	2	2.302	4913	$2\frac{1}{8}$	4.76	3.63	1.13

NOTES:—Bolt holes should straddle center lines. Flanges should have $\frac{1}{16}$-in. raised face for gaskets.

Square head bolts with hexagonal nuts are recommended. For bolts $1\frac{5}{8}$ in. diameter and larger stud with a nut at each end is satisfactory.

Hexagonal nuts for pipe sizes 1 in. to 16 in. can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 18 in. to 48 in. can be conveniently pulled up with box or socket wrenches.

RULES approximately followed in compiling above data:

Bolt circle $= 1.171\,D + 3.75$

Flange thickness $= 0.0546\,D \times 1.375$

D = inside diameter of pipe

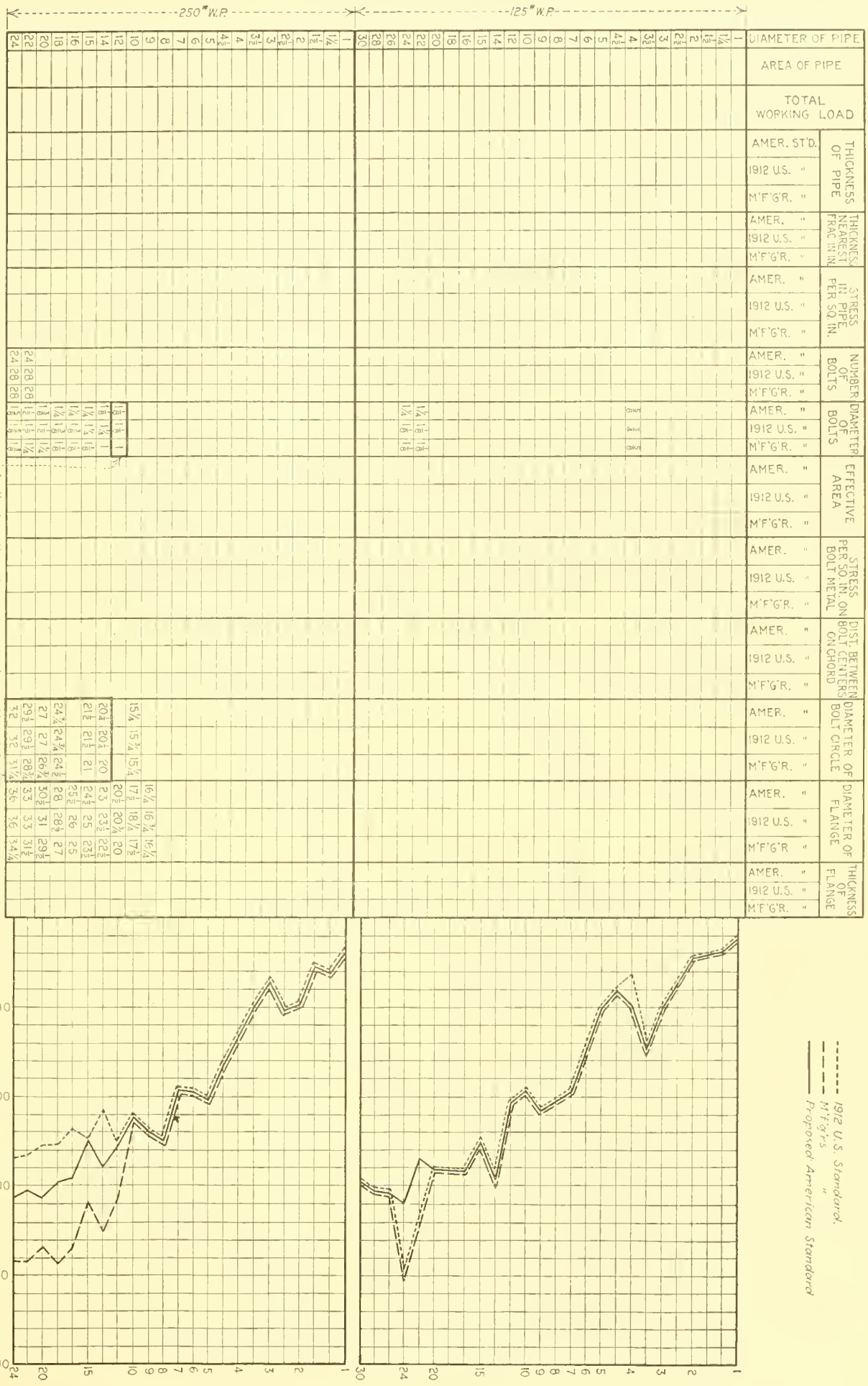


Fig. 1 Comparison of American Standard, 1912 U. S. Standard and Manufacturers' Standard, showing where Differences Occur

TABLE 3 AMERICAN STANDARD, 125-LB. WORKING PRESSURE PER SQ. IN. STANDARD FLANGED FITTINGS, STRAIGHT SIZES

	Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30	32	34	36	38	40
A-A	Face to Face	7	7½	8	9	10	11	12	13	14	15	16	17	18	20	22	24	28	29	30	33	36	40	44	46	48	50	52	54	56	58	60
A	Center to Face	3½	3¾	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	11	12	14	14½	15	16½	18	20	22	23	24	25	26	27	28	29	30
B	Center to Face of Long Radius Ells	5	5½	6	6½	7	7¾	8½	9	9½	10¼	11½	12¾	14	15¼	16½	19	21½	22¾	24	26½	29	31½	34	36½	39	41½	44	46½	49	51½	54
C	Center to Face of 45-Deg. Ells	1¾	2	2¼	2½	3	3	3½	4	4	4½	5	5½	5½	6	6½	7½	7½	8	8	8½	9½	10	11	13	14	15	16	17	18	19	20
D	Face to Face Laterals	7½	8	9	10½	12	13	14½	15	15½	17	18	20½	22	24	25½	30	33	34½	36½	39	43	46	49½	53	56	59					
E	Center to Face	5¾	6¼	7	8	9½	10	11½	12	12½	13½	14½	16½	17½	19½	20½	24½	27	28½	30	32	35	37½	40½	44	46½	49					
F	Center to Face	1¾	1¾	2	2½	2½	3	3	3	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8	8½	9	9	9½	10					
G	Face to Face Reducer						6	6½	7	7½	8	9	10	11	11½	12	14	16	17	18	19	20	22	24	26	28	30	32	34	36	38	40
	Diameter of Flange	4	4½	5	6	7	7½	8½	9	9¼	10	11	12½	13½	15	16	19	21	22¼	23½	25	27½	29½	32	34¼	36½	38¾	41¾	43¾	46	48¾	50¼
	Thickness of Flange	7/16	1/2	9/16	5/8	11/16	3/4	13/16	15/16	15/16	15/16	1	1 1/16	1⅛	1⅛	1 3/16	1¼	1⅜	1⅜	1 7/16	1 9/16	1 11/16	1 13/16	1⅞	2	2 1/16	2⅛	2¼	2 5/16	2⅜	2⅜	2½
	Diameter of Bolt Circle	3	3⅜	3⅞	4¾	5½	6	7	7½	7¾	8½	9½	10¾	11¾	13¼	14¼	17	18¾	20	21¼	22¾	25	27¼	29½	31¾	34	36	38½	40½	42¾	45¼	47¼
	No. of Bolts	4	4	4	4	4	4	4	8	8	8	8	8	8	12	12	12	12	16	16	16	20	20	20	24	28	28	28	32	32	32	36
	Diameter of Bolts	7/16	7/16	1/2	5/8	5/8	5/8	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	7/8	7/8	1	1	1	1¼	1⅛	1¼	1¼	1¼	1¼	1⅜	1½	1½	1½	1⅝	1⅝
	Minimum Metal Thickness of Body	7/16	7/16	7/16	7/16	7/16	7/16	7/16	1/2	1/2	1/2	9/16	5/8	5/8	11/16	3/4	13/16	7/8	7/8	1	1 1/16	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16	1½	1 9/16	1⅝	1 11/16	1¾

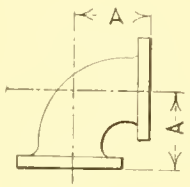
	Size	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
A-A	Face to Face	62	64	66	68	70	74	78	82	84	88	90	94	96	100	102	106	108	112	116	118	120	124	126	130	134	136	138	142	146	148
A	Center to Face	31	32	33	34	35	37	39	41	42	44	45	47	48	50	51	53	54	56	58	59	60	62	63	65	67	68	69	71	73	74
B	Center to Face of Long Radius Ells	56½	59	61½	64	66½	69	71½	74	76½	79	81½	84	86½	89	91½	94	96½	99	101½	104	106½	109	111½	114	116½	119	121½	124	126½	129
C	Center to Face of 45-Deg. Ells	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
D	Face to Face Laterals																														
E	Center to Face																														
F	Center to Face																														
G	Face to Face Reducer	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
	Diameter of Flange	53	55¼	57¼	59½	61¾	64	66¼	68¾	71	73	75¾	78	80	82¼	84½	86½	88½	90¾	93	95¼	97½	99¾	102	104¼	106½	108¾	111	113¼	115½	117¾
	Thickness of Flange	2⅝	2⅝	2 11/16	2¾	2¾	2⅞	3	3	3⅛	3⅛	3¼	3¼	3⅜	3⅜	3½	3½	3⅝	3⅝	3¾	3¾	3⅞	3⅞	4	4	4⅛	4⅛	4¼	4¼	4⅜	4⅜
	Diameter of Bolt Circle	49½	51¾	53¾	56	58¼	60½	62¾	65	67¼	69¼	71¾	74	76	78¼	80½	82½	84½	86½	88¾	91	93¼	95½	97¾	100	102¼	104½	106¾	108½	110¾	113
	No. of Bolts	36	40	40	44	44	44	44	48	48	52	52	52	52	56	56	60	60	60	60	60	60	64	64	68	68	68	68	68	68	68
	Diameter of Bolts	1⅝	1⅝	1⅝	1⅝	1¾	1¾	1¾	1¾	1¾	1¾	1⅞	1⅞	1⅞	1⅞	1⅞	1⅞	1⅞	1⅞	2	2	2	2	2	2	2⅛	2⅛	2⅛	2¼	2¼	2¼
	Minimum Metal Thickness of Body	1 13/16	1⅞	1 15/16	2	2 1/16	2⅛	2 3/16	2¼	2 5/16	2 7/16	2½	2 9/16	2⅝	2 11/16	2¾	2 13/16	2⅞	2 15/16	3	3 1/16	3⅛	3 3/16	3¼	3 5/16	3⅜	3½	3 9/16	3⅝	3 11/16	3¾

NOTES:—Figures given are for center to face and for face to face finished dimensions. Where necessary manufacturers will make suitable allowances in patterns before casting.
Laterals do not extend beyond the 30-in. size at the present time. Box wrench to be used on bolting for large sizes.
Square head bolts with hexagonal nuts are recommended. 1⅝ in. diameter and larger stud with a nut at each end is satisfactory.
Hexagonal nuts for pipe sizes 1 in. to 46 in. can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 48 in. to 100 in. can be conveniently pulled up with socket wrenches.

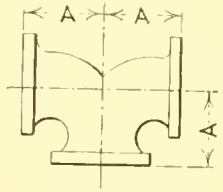
TABLE 4 AMERICAN STANDARD, 250-LB. WORKING PRESSURE PER SQ. IN., EXTRA HEAVY FLANGED FITTINGS, STRAIGHT SIZES

	Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
A-A	Face to Face	8	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	31	33	36	39	41	45	48	52	55	58	61	65	68	71	74	78	81	84
A	Center to Face	4	4¼	4½	5	5½	6	6½	7	7½	8	8½	9	10	10½	11½	13	15	15½	16½	18	19½	20½	22½	24	26	27½	29	30½	32½	34	35½	37	39	40½	42
B	Center to Face of Long Radius Ells	5	5½	6	6½	7	7¾	8½	9	9½	10¼	11½	12¾	14	15¼	16½	19	21½	22¾	24	26½	29	31½	34	36½	39	41½	44	46½	49	51½	54	56½	59	61½	64
C	Center to Face of 45-Deg. Ells	2	2½	2¾	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8	8½	9	9½	10	10½	11	12	13	14	15	16	17	18	19	20	21	22	23	24
D	Face to Face, Laterals	8½	9½	11	11½	13	14	15½	16½	18	18½	21½	23½	25½	27½	29½	33½	37½	39½	42	45½	49	53	57½	...	...	...	...	...	...	...	...	...	...	...	...
E	Center to Face, Laterals	6½	7¼	8½	9	10½	11	12½	13½	14½	15	17½	19	20½	22½	24	27½	31	33	34½	37½	40½	43½	47½	...	...	...	...	...	...	...	...	...	...	...	...
F	Center to Face, Laterals	2	2¼	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5	5½	6	6½	6½	7½	8	8½	9½	10	...	...	...	...	...	...	...	...	...	...	...	...
G	Face to Face, Reducer	...	...	...	...	...	6	6½	7	7½	8	9	10	11	11½	12	14	16	17	18	19	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
	Diameter of Flange	1½	5	6	6½	7½	8¼	9	10	10½	11	12½	14	15	16¼	17½	20½	23	24½	25½	28	30½	33	36	38¼	40¾	43	45¼	47½	50	52¼	54½	57	59¼	61½	65
	Thickness of Flange	11/16	¾	13/16	⅞	1	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16	1½	1⅝	1¾	1⅞	2	2⅛	2 3/16	2¼	2⅜	2½	2⅝	2¾	2 13/16	2 15/16	3	3⅛	3¼	3⅜	3 7/16	3 9/16	3 11/16	3¾	3⅞	4
	Diameter of Bolt Circle	3¼	3¾	4½	5	5⅞	6⅝	7¼	7⅞	8½	9¼	10⅝	11⅞	13	14	15¼	17¾	20¼	21½	22½	24¾	27	29¼	32	34½	37	39¼	41½	43½	46	48	50¼	52¾	55	57¼	60¾
	No. of Bolts	4	4	4	4	4	8	8	8	8	8	12	12	12	12	16	16	20	20	20	24	24	24	24	28	28	28	28	28	32	32	36	36	36	40	40
	Diameter of Bolts	½	½	⅝	⅝	¾	¾	¾	¾	¾	¾	¾	⅞	⅞	1	1	1⅛	1⅛	1¼	1¼	1¼	1⅜	1½	1⅝	1⅝	1⅝	1¾	1⅞	1⅞	1⅞	1⅞	1⅞	1⅞	2	2	2
	Minimum Metal Thickness of Body	½	½	½	½	9/16	9/16	9/16	⅝	⅝	11/16	¾	13/16	13/16	⅞	15/16	1	1⅛	1 3/16	1¼	1⅜	1½	1 9/16	1⅝	1 13/16	1⅞	2	2⅛	2¼	2⅜	2 7/16	2 9/16	2 11/16	2 13/16	2⅞	3

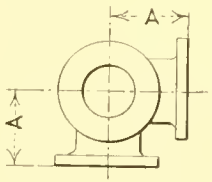
NOTES:—Figures given are for center to face and for face to face finished dimensions. Where necessary manufacturers will make suitable allowances in patterns before casting.
Laterals do not extend beyond the 24-in. size at the present time. Box wrench to be used on bolting for large sizes.
Square head bolts with hexagonal nuts are recommended. 1⅝ in. diameter and larger stud with a nut at each end is satisfactory.
Hexagonal nuts for pipe sizes 1 in. to 16 in. can be conveniently pulled up with wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 18 in. to 48 in. can be conveniently pulled up with socket wrenches.



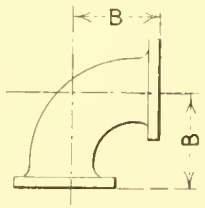
90° ELL



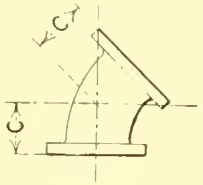
DOUBLE BRANCH ELL



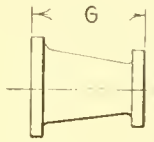
SIDE OUTLET ELL



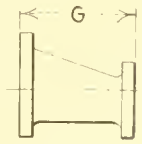
LONG RADIUS ELL



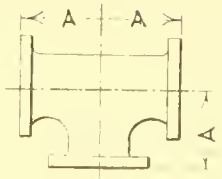
45° ELL



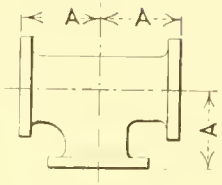
REDUCER



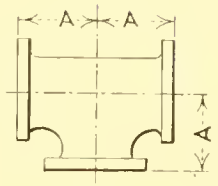
ECCENTRIC REDUCER



TEE



SINGLE SWEEP TEE



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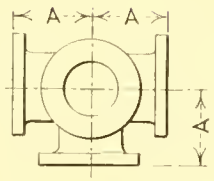
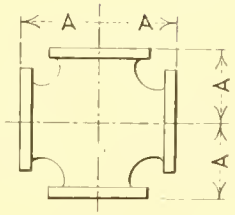
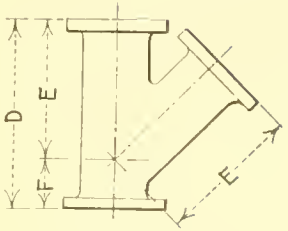


SIDE OUTLET TEE



CROSS



LATERAL

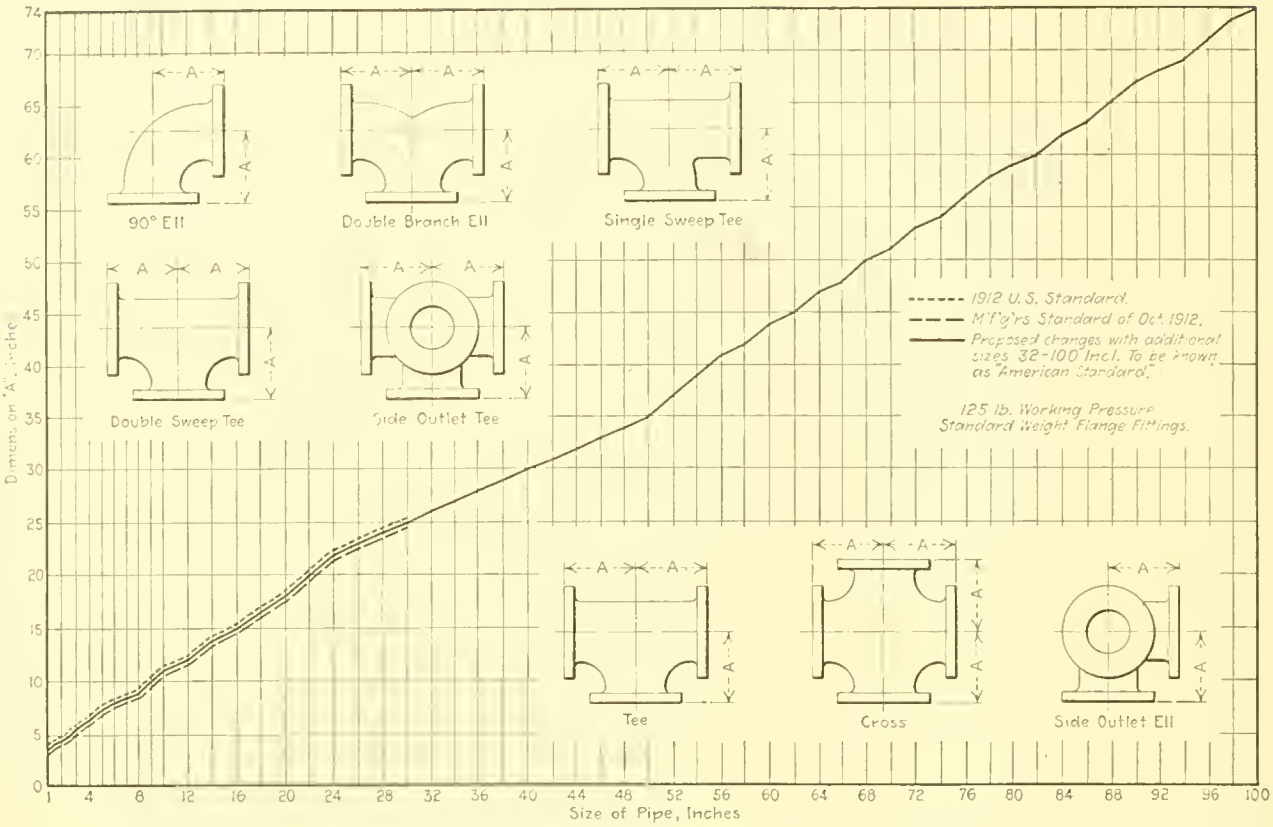


Fig. 2 Comparison of 1912 U. S. Standard, Manufacturers' Standard and Proposed Changes in Center to Face Dimensions Ells, Tees and Crosses for 125 lb. Working Pressure

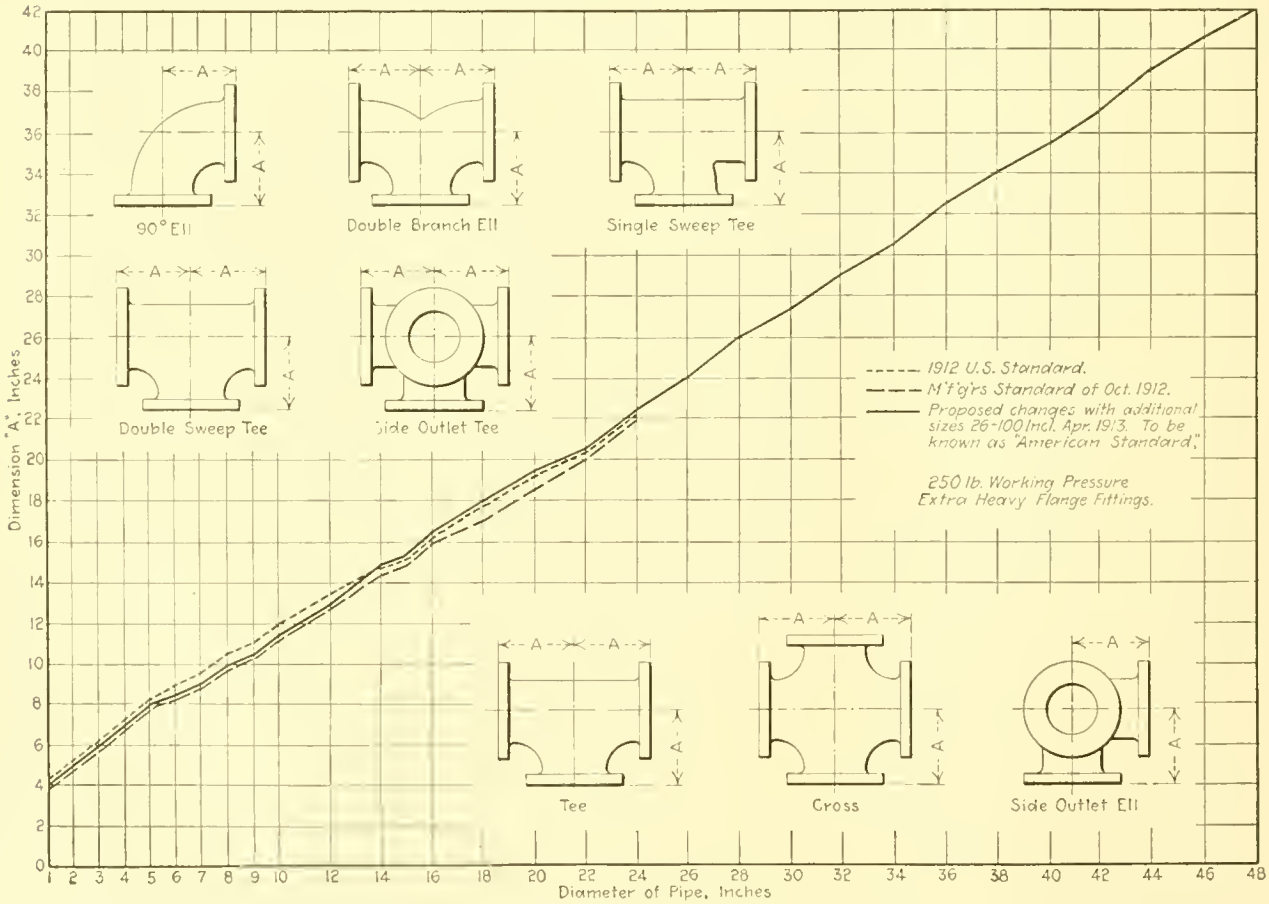


Fig 3 Comparison of 1912 U. S. Standard, Manufacturers' Standard and Proposed Changes in Center to Face Dimensions, Ells, Tees and Crosses for 250 lb. Working Pressure

or eccentric, for all pressures, shall be the same face to face as given in table of dimensions.

i Square head bolts with hexagonal nuts are recommended.

For bolts, 1⅝ in. diameter and larger, studs with a nut on each end are satisfactory.

Hexagonal nuts for pipe sizes 1 in. to 46 in., on 125-lb. standard, and 1 in. to 16 in. on 250-lb. standard can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 48 in. to 100 in. on 125-lb. and 18 in. to 48 in. on 250-lb. standards, can be conveniently pulled up with box or socket wrenches.

j Twin Elbows, whether straight or reducing, carry same dimensions center to face and face to face as regular straight size ells and tees.

Side Outlet Elbows and Side Outlet Tees, whether straight or reducing sizes, carry same dimensions center to face and face to face as regular tees having same reductions.

k Bull Head Tees or Tees increasing on outlet, will have same center to face and face to face dimensions as a straight fitting of the size of the outlet.

l Tees and Crosses 9 in. and down, reducing on the outlet, use the same dimensions as straight sizes of the larger port.

Size 10 in. and up, reducing on the outlet are made in two lengths depending on the size of the outlet as given in the table of dimensions.

Laterals 3½ in. and down, reducing on the branch, use the same dimensions as straight sizes of the larger port.

m Sizes 4 in. and up, reducing on the branch, are made in two lengths depending on the size of the branch as given in the table of dimensions.

The dimensions of reducing flanged fittings are always regulated by the reductions of the outlet or branch. Fittings reducing on the run only, the long body pattern will always be used.

Y's are special and are made to suit conditions.

Double sweep tees are not made reducing on the run.

n Steel Flanges, Fittings and Valves are Recommended for Superheated Steam.

Respectfully submitted,

H. G. Stott, *Chmn.*
A. C. Ashton
A. R. Baylis
Wm. Schwanhausser
J. P. Sparrow
Members of Committee on Standardization of Flanges

W. M. McFarland, member of the Committee, heartily concurs in the above report except that he would like to see the principle of interchangeability carried out as far as practicable.

DISCUSSION

E. D. Denny[1] referred to the prominence and high professional ability of the members of the committees of the two societies which had been engaged on this problem. These men all worked diligently in the preparation of the 1912 U. S. Standard Schedule and many meetings were held for a comparison of views and a discussion of the various problems involved. When the final vote was taken on the finished schedule, it was adopted unanimously. In all this preparatory work there was no discussion of the differences between the proposed schedule and the existing schedules of the various manufacturers, no two of which were at that time alike. The only thought was to make a schedule that would provide the requisite, without excessive, strength, and that would make all side or lateral outlet fittings of the same size run interchangeable. The practical wisdom of the work of these committees is evidenced by the fact that their work has never been successfully attacked. A significant testimonial to the intrinsic merit of the schedule may be found in the action of the various departments of the U. S. Government. Up to July 1911 all Government specifications calling for flange fittings described such fittings in detail; but as soon as the 1912 U. S. Schedule was issued and came to the attention of these Government experts it was adopted by one department after another—they saw that it had been prepared from the engineering standpoint and not from the commercial standpoint. Today practically every Government specification calling for flanged fittings provides that they must be in accord with the 1912 U. S. Standard.

There has been great opposition, both open and covert, to the universal adoption of this standard, but it has been based almost entirely on the expense that would attend the alteration of patterns. This was brought out at the hearing in Washington. The brief prepared by the Manufacturers' Association admitted the need of a uniform standard and tacitly admitted the intrinsic merits of the 1912 U. S. Standard Schedule, but it violently protested that it would be very expensive to alter existing patterns to conform to it. Then the Commissioner—the chairman of the meeting—quietly said: "You admit that there should be a uniform schedule, that the schedules of the various manufacturers are not now uniform—how would you ever get a uniform schedule without the expense of altering patterns?"

It would seem that there was but one wise plan for both these societies to pursue under such conditions. Several of the manufacturers have already altered their patterns, or made new patterns, and since July, 1912, it has been possible to get all sizes of flanged fittings in accordance with the 1912 U. S. Schedule and at as low prices as such fittings could be bought of other manufacturers whose schedules were different. It may be true that certain manufacturers have refused thus far to furnish such fittings at regular prices, but that would not be a sufficient reason for us to recede from a position that was deliberately taken after careful consideration.

It was the same some years ago when our societies in a similar manner issued the Schedule of Standard Flanges. Many of the manufacturers refused to accept it and for the same reason that they now refuse to accept the 1912 U. S. Standard Schedule—the expense of altering patterns. I think it was three years before the last most stubborn concern fell into line, but by our persistent insistence upon it the schedule was finally universally adopted and who can compute the benefit it has been to us for ten years past.

As the matter comes before the Society at this time it is in the form of a resolution, not simply to reopen the subject, but actually to cast aside the schedule which cost so much labor and expense to both societies, and which is very generally admitted to be practically perfect, but to adopt another schedule lacking the most important features of the one that was unanimously adopted and approved less than two years ago. There seems to be no argument for such a

[1] President, National Association of Master Steam and Hot Water Fitters.

course, except that unless we thus stultify ourselves, certain manufacturers will refuse to adopt our schedule, not because it is in anywise defective, but because they will not be at the expense of altering the patterns.

N. Loring Danforth read a history of the work of standardization that had been done by the National Association of Master Steam and Hot Water Fitters and The American Society of Mechanical Engineers. This had been prepared by himself, William T. English and Earnest T. Child, all members of both societies, and was printed for distribution at the meeting. The most essential points are given in the following abstract:

The standardization of flanges and flanged fittings was taken up by the National Association of Master Steam and Hot Water Fitters in 1905, at which time the manufacturers were invited to join them in preparing a standard; and in May, 1908, a request was received from The American Society of Mechanical Engineers to join in preparing a standard, which the Master Steam and Hot Water Fitters were very glad to have them do. While the manufacturers agreed that a standard was necessary, efforts to have them confer jointly with the two committees were unsuccessful.

The standard known as "The 1912 U. S. Standard" was adopted by the joint committee of the two societies in March, 1911: by the convention of the Master Steam and Hot Water Fitters in May, 1911, subject to slight changes; and in October, 1911, these final details were agreed upon by the joint committee.

In the fall of 1911 the 1912 U. S. Standard Schedule was recommended by the A.S.M.E. committee to the Council of the Society, presented to the Annual Meeting in December, and accepted and printed in the February, 1912, issue of The Journal.

The 1912 U. S. Standard has also been adopted by the Bureau of Standards of the United States Government, the Bureau of Yards and Docks of the United States Navy Department; and has been specified by the Department of the Interior, Department of Justice and Bureau of Supplies and Accounts, as well as by many consulting engineers, members of the A.S.M.E.

It was deemed advisable to confer with the American Water Works Association and the New England Water Works Association, as they are the principal users of fittings and flanges of the larger sizes. Through the efforts of the Master Steam and Hot Water Fitters a meeting was held in December, 1912, at which were present the chairmen of the committees of the four associations already mentioned. At this meeting the chairman of the A.S.M.E. committee presented a tentative schedule, regarding which it was agreed that the chairmen of the two waterworks associations' committees should check up the schedule and see if it would work in with the dimensions of the large size pipe used in waterworks construction.

About this time a prominent manufacturer began to realize that the 1912 U. S. Standard was becoming universally adopted and certain paragraphs appeared in various technical journals to the effect that manufacturers would not recognize that standard; that it was not definitely adopted and that it was to be revised or changed.

In the August, 1912, issue of The Journal of the A.S.M.E. appears the statement that "The Committee of The American Society of Mechanical Engineers have decided after the most careful consideration not to reopen the subject, as has been erroneously reported." This and other statements of similar purport have led the Master Steam and Hot Water Fitters to believe that the A.S.M.E. would not recede from its position.

In March, 1913, the chairman of the A.S.M.E. committee advised the Master Steam and Hot Water Fitters that he had held a number of conferences with the representative of a prominent manufacturer concerning a compromise schedule. It was a great surprise to learn this in view of his repeated statements that he would not entertain any change in the 1912 U. S. Standard. He then suggested to the chairman of the Master Steam and Hot Water Fitters' committee that a meeting of the two commitees be held (in May, 1913), and an effort in that direction was made, but owing to the nearness of the convention of the latter society and other engagements, it was found impossible to meet on the desired date and the chairman was so advised.

On June 4, 1913, the chairman of the A.S.M.E. committee advised the chairman of the Master Steam and Hot Water Fitters' committee that "The Committee on Standardization of Flanges of the A.S.M.E. had yesterday adopted by unanimous vote the new compromise standard known as the 1914 American Standard." The meeting referred to was held, absolutely ignoring the Association of Master Steam and Hot Water Fitters.

In view of the fact that the committees of the two associations had been working together so harmoniously for a period of more than two years, and that the 1912 U. S. Standard had not only been adopted by the joint committee, but confirmed by the National Association of Master Steam and Hot Water Fitters in convention assembled and by the Council of The American Society of Mechanical Engineers, we were astounded at the communication just quoted—especially, in view of the fact that the former association took the initiative and that the latter Society requested the opportunity to work with them on this question of preparing a standard for flanged fittings and flanges.

The printed statement further goes on to say that at one largely attended conference of the two committees the subject of the compromise schedule was fully discussed and that the representatives of the Master Steam and Hot Water Fitters were ready to adopt certain dimensions of flanges and fittings called for, provided, first, that the manufacturers would eliminate their short body fittings, thereby maintaining the interchangeable feature which was so important a feature in the 1912 U. S. Standard; second, that the name of this compromise should be the 1912 U. S. Standard, revised January 1st, 1914; and third that it should include the larger sizes of flanges after the dimensions of these larger flanges had been approved by the American Water Works Association and the New England Water Works Association.

It was felt that this was a very liberal concession and in view of this resolution, the chairmen of both committees were to confer with the chairman of the manufacturers' committee with a view to the ultimate adoption of this revised and enlarged schedule. No conference was arranged, but correspondence between the chairman of the A.S.M.E. committee and the chairman of the manufacturers' committee indicated that the concessions suggested were not agreeable to the latter. The committee of the Master Steam and Hot Water Fitters has therefore concluded that the 1912 U. S. Standard should be maintained. The members of this association and those who are affiliated with them and who have

adopted this standard are without question the largest consumers of these goods in the United States and the interchangeability feature of the 1912 U. S. Standard would mean a very large saving to them.

HENRY B. GOMBERS[1] said he had been asked by Mr. John H. Gregory, chairman of the Committee on Standardization of the American Water Works Association, to give as his opinion that it would be a great mistake to take any step looking toward a change of the 1912 U. S. Standard Schedule until after a conference had been held, in which every society interested in the matter was represented. He also confirmed what President Denny had said about the hearing in Washington. Mr. Stott had very ably sustained the position which he had taken with regard to the 1912 U. S. Standard with many excellent arguments. A month ago Mr. Gombers was in Washington and found that the views of the departments interested had not changed. They are still specifying material in accordance with the 1912 U. S. Standard and as evidence he exhibited a copy of the general schedule of supplies for the fiscal year 1914 dealing with electrical, engineering and plumbing supplies, in which the 1912 U. S. Standard is specified.

E. T. CHILD said there are many more changes in the report than would be inferred. The committee of the Master Steam and Hot Water Fitters' Association has counted up and listed these changes, and finds that there are over 250 of them. They have also compared the proposed schedule with various catalogue dimensions and find that it tallies more nearly with those of one manufacturer than with any other of the lot. Does the Society want to stultify itself to the extent of adopting the schedule of one manufacturer and putting all the others aside, especially when the 1912 U. S. Standard is conceded to be theoretically correct?

WILLIAM T. DONNELLY said that as a broad proposition, covering any committee report, he was opposed to throwing away one standard and adopting another. Having accepted any standard he thought it was not within the bounds of good practice to throw it away and adopt another; but that the one we already have should be revised.

CHARLES WHITING BAKER asked if the Committee on Standardization of Flanges had not been discharged when its previous report was submitted, or if the report had been referred back to the committee for further action and amendment; and also, if the new standard were adopted whether it would necessitate changes by some of the manufacturers who had already adopted the 1912 U. S. Standard. Mr. Stott replied: The standard was never taken out of the hands of the committee; the committee was not discharged and was at liberty to proceed with its work. The new standard has been adopted by the Manufacturers' Association which embodies 90 per cent of the output of flanges and fittings in the United States. There may be one or two who have adopted the 1912 U. S. Standard and some, he understood, who used the Independent Standard.

WALTER M. MCFARLAND, speaking as a member of the committee of The American Society of Mechanical Engineers, explained that while he sympathized with his friends of the Master Steam and Hot Water Fitters' Association about one or two of the points they were making, he wanted to add something to what had been said to show exactly what the conditions are. He emphasized the extreme difficulty that had been experienced in securing the coöperation of the manufacturers with respect to the 1912 U. S. Standard, saying in part:

After the two committees had agreed on the report containing this standard we met a committee of the Manufacturers' Association and were received very courteously at the beginning, but later on found they were not disposed to adopt the report or to have anything to do with it. We then arranged for another meeting of the committees representing The American Society of Mechanical Engineers and the Master Steam and Hot Water Fitters' Association, to which we urgently invited the manufacturers to send representatives, but so far as I can now remember they did not respond even to the invitation, and certainly did not send representatives.

A second effort was made to get the manufacturers to meet with the representatives of the two organizations referred to, but only one gentleman came, who distinctly said he came in his individual capacity, and in no sense as a representative of the Manufacturers' Association. In other words, the point I am trying to bring out is that up to the time of the adoption and promulgation of the 1912 U. S. Standard, the manufacturers had treated us with extreme discourtesy.

Thereafter, when the 1912 U. S. Standard was issued and was evidently going to be adopted by a great many people, some of the manufacturers shifted over. Then the manufacturers woke up and came to the conclusion that they had made a mistake and there was a disposition to get into line.

In my judgment, Mr. Stott was right when he was willing to meet these people and see if something could not be done to draw them all in. When we consider the subject carefully, we must understand that standards are not things to be worshipped, but ought to be things that, while substantially correct and as nearly perfect as possible, recommend themselves to the largest number of people interested.

Owing to an unfortunate misunderstanding, the joint meeting of the committees of The American Society of Mechanical Engineers and the Master Steam and Hot Water Fitters' Association, which was scheduled for some time in May of this year, did not come off, and, as I am given to understand, it was supposed for a time that the not respond even to the invitation, and certainly did not want to go on with any further discussion. However that may be, the discussion was continued with the manufacturers and a compromise was agreed upon.

Now here is where the manufacturers were wrong: As soon as the committee made its report, and before it could be brought up for discussion, the manufacturers published it and stated that it was to be the standard. Subsequently, the Committee of the Master Steam and Hot Water Fitters' Association, as they say in the printed statement read by Mr. Danforth, came to the point where, if they could have the principle of interchangeability carried out and could retain the name as the 1912 U. S. Standard *Revised*, they were willing to concede a number of other things. We asked Mr. Stott to take up these features with the manufacturers, as it seemed to most of us that the request was not an unreasonable one. The manufacturers replied, however, that they had already published a lot of literature and did not see how they could

[1] Secretary, National Association of Master Steam and Hot Water Fitters.

make any change. That, however, is no logical reason at all for declining to do so when we consider all the matter which this Society and the Master Steam and Hot Water Fitters' Association has put out about the other standard. As I understand it, this is the condition of affairs to-day.

A. R. Baylis (contributed). The 1912 U. S. Standard ends at 30 in. for the 125-lb. and 24 in. for the 250-lb., while the American Standard, barring laterals, includes brand new sizes up to 100 in. for the 125-lb. and 48 in. for the 250-lb., and the question of desirability of making changes in the 1912 U. S. Standard would have probably gone unnoticed had it not been for the great number of new sizes now included in the American Standard. There has been probably as much time, effort and work expended on devising the additional sizes mentioned as that claimed by the Master Steam and Hot Water Fitters' Association in the 1912 U. S. Standard, with the added difficulty of blending the larger sizes of the American Standard with the smaller ones of the 1912 Standard in such a way that the large sizes of the American Standard would not appear absurdly excessive in dimensions, and that the complete standard would show just as much uniformity of design in the smaller, as in the larger sizes. A careful inspection of the book of curves of bolt circles, flange diameters and thicknesses, center to face dimensions of fittings, etc., of the American Standard will show with what degree of success it compares with the curves shown for the 1912 Standard.

It has been claimed by the Master Steam and Hot Water Fitters' Association that there have been 250 changes made in the 1912 Standard. In reference to flanges and bolting, contained in the rather contracted scope of the 1912 Standard sizes, Fig. 16 of the committee's report (Fig. 1 herewith) would indicate about 18 changes. The American Standard bolt stress curves clearly show the advantage over the other curves. As a great part of the stress in a small bolt is due to making up a tight joint, it seems advisable to figure for a low stress due to live load. As the diameter of the bolt increases, the initial stress per sq. in. of bolt metal due to making up a tight joint bears a smaller proportion to the stress per sq. in. of bolt metal due to live load. This latter stress can be increased within safe limits in proportion as the diameter of the bolt increases; in fact, in the very large sizes of the American Standard, 250-lb. weight, it was found difficult to keep the bolt stresses much below 5000 lb. per sq. in. on account of not having enough room to spare between nuts for wrenches. It, therefore, appeared reasonable to start at the 10-in. size with the bolt stress of 2231 lb. and gradually increase to 4913 lb. per sq. in. on the 48-in. size. In regard to the remaining changes in lengths of fittings within the scope of the 1912 U. S. Standard sizes, with the exception of reducing fittings, most of the changes are practically invisible to the eye when plotted to scale, and where there is a visible change the American Standard evidently shows to advantage.

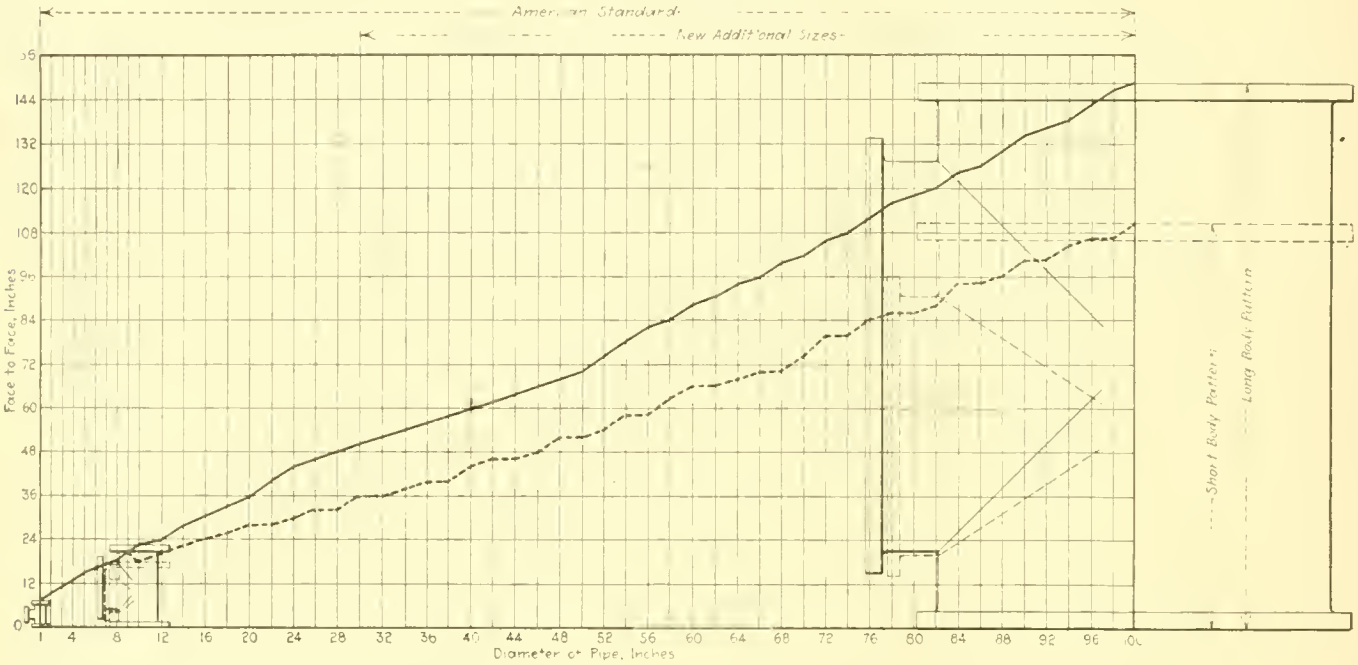


Fig. 4 Curves showing Face to Face Dimensions of Long and Short Body Tees and Crosses, 125 lb. Working Pressure

Another point in the American Standard that may be worthy of mention, is that pertaining to minimum pipe wall thicknesses. This was not considered in the 1912 U. S. Standard, although it certainly seems to be more important than a slight change in a face to face dimension of a fitting, as it involves the strength of the fitting, while the face to face dimension is simply a question of more or less length.

Interchangeability in the American Standard has not only been carried out for the sizes 1 to 10 in., but extended throughout the entire list in the long body patterns. Another class of interchangeability also exists in short body patterns. For economy's sake, the short body patterns have been standardized for sizes of outlets so small in diameter as to warrant a shorter length of body. The difference in length of run between the two patterns is shown graphically in Figs. 4 and 5.

In consideration of the fact that the cost per running foot

of cast-iron fittings is, approximately, twice that per running foot of cast-iron pipe, and four times that of pipe with cast steel as a basis, it seems advisable to include the short body patterns within reasonable limits for diameters of outlets. Take, for instance, a 125-lb., 100 in. by 100 in. by 98 in. reducing tee; this fitting has dimensions that are interchangeable with standard and reducing tees and crosses with outlets as small as 68 in. in diameter, the length face to face being 148 in., and center to face of outlet 74 in.; for all reduction of outlets below 68 in. diameter, the face to face dimension is 110 in. Would any good engineer consider it economical or advantageous to design a fitting (148 in.—110 in.), or 38 in. longer than necessary in order to make it interchangeable with all other fittings, when the difference in cost per foot is as stated above, especially when perhaps only one plant out of many may have occasion to replace a tee with a cross.

Figs. 4 and 5 of face to face dimensions are given to indicate graphically why a long and short body pattern is advisable between the limits of 10 in. to 100 in. on the 125-lb., and 10 in. to 48 in. on the 250-lb.

H. G. Stott, in closing, said that several statements had been made in the discussion which were at variance with the facts. One of these is that the U. S. Government in all its departments has continued to use the 1912 U. S. Standard.

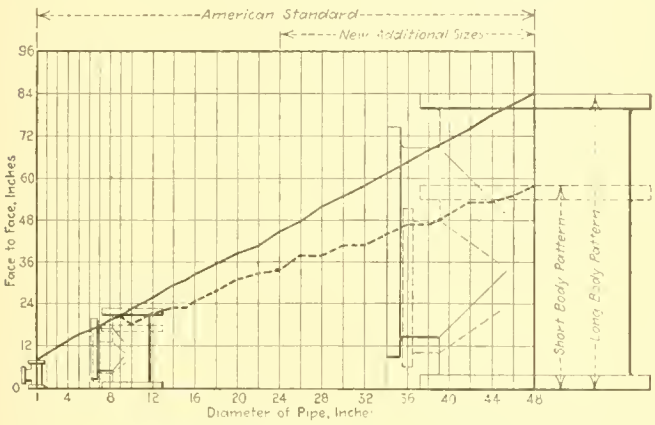


Fig. 5 Curves Showing Face to Face Dimensions of Long and Short Body Tees and Crosses, 250 lb. Working Pressure

He had a letter from Dr. Stratton, director of the Bureau of Standards, dated April 3, 1913, which expressed the desire of the Bureau to use its offices in bringing together the various interests with a view to effecting the standardization of flanges and flange fittings. This did not indicate the present acceptance of a standard by that department and the Navy Department has its own standard with bolt circles entirely different from the 1912 U. S. Standard.

Also, in the matter of changes in the present report. Referring to Figs. 2 and 3 (in this issue), there will be found a comparison of dimensions of ells, tees and crosses for the Manufacturers' Standard, the 1912 U. S. Standard and the proposed American Standard. It will be seen that the differences in dimensions are almost infinitesimal. This is only a sample and a review of the other comparative curves of the report will show that the changes proposed are slight and in the nature of compromises between the Manufacturers' Standard and the 1912 U. S. Standard.

The Committee's report is identical with that of the committee of the Manufacturers' Association which has been adopted by them and is being published in manufacturers' catalogues. The general broad principles of compromise followed in the meetings with the Manufacturers' Association were these: That they would adopt our stresses and bolt circles and diameter of bolts and we would adopt as much as possible of their fittings. In working to that it became necessary for the manufacturers to change many of their standard dimensions of fittings. He said further:

In engineering matters we are probably never able to realize the ideal. Practically all engineering is the result of compromise. We found in actual practice that we were unable to get the 1912 U. S. Standard fittings on the market from the firms with whom we were dealing without paying an additional price. In other words, these were not standard fittings. This complaint came from innumerable firms. The attitude of two of the large railroad companies was a decisive factor in the determination that we should not adopt the 1912 U. S. Standard. I appealed to the engineers of these railroads personally, and asked them why they did not adopt this standard, and they said they could do nothing with the purchasing department on this basis.

In regard to interchangeability, all tees and crosses in the American Standard are interchangeable up to and including 9 in., the same as in the 1912 U. S. Standard. Beyond that all long body tees and crosses are interchangeable among themselves and all short body tees and crosses are interchangeable among themselves. It must be remembered that in this report we have extended the dimensions of the standard weight fittings from 30 in. to 100 in., for the light, and from 24 in. to 48 in. for the heavy. The demand for these sizes has come up from time to time, not only from the waterworks people, but from others who have use for these large sizes: for example, in large turbine work exhaust pipes up to 100 in. are not unusual. These sizes have been carried up consistently. In drawing any curve it is a well known fact that the upper points of the last ends of curves are usually indefinite, because there are no further points determined, so in going up to the larger sizes some of the other points were found not to conform to that curve, and therefore they were changed.

In regard to the two waterworks associations, their statement was this: That until they settled their own differences, one of the principal being whether the dimension of the pipe should be inside or outside, there was no use in trying to do anything with them, and as our own people required these larger sizes, we went ahead and developed the standard as given here.

The attitude taken by the Master Steam and Hot Water Fitters' Association is astonishing. At the last conference with them they agreed to the new schedule as presented here, except that they demanded first that it should be called "The 1912 Standard, Revised," instead of "The American Standard of 1914," and second that all tees and crosses should be made interchangeable. This leaves only the name and the tees and crosses over 10 in. in size as debatable ground. A copy of this resolution was sent to their chairman, Mr. English, which he approved except that he said there was not sufficient emphasis on the fact that the name should be retained. There has not been a single technical question raised in this discussion; the subject is treated entirely as a question of policy. Your committee has spent an enormous amount of time on the development of the standard, and given careful

consideration to the matter in all its aspects, and believes the report as now presented is a much more consistent and logical standard than the one which contained the 1912 U. S. Standard. If any of us cannot improve on our past work, three years old, we should admit that we are not progressive, and that there is no evolution in the engineering profession. Three years from now there will be points discovered wherein this present standard can be improved.

MOTION BY MR. ROCKWOOD

George I. Rockwood pointed out that one of the chief uses for fittings is in the automatic sprinkler business for fire protection, and that there are two governing bodies which control every dimension and every bit of material which goes into sprinkler systems. They are the Underwriters' Laboratories in Chicago and The Associated Factory Mutual Fire Insurance Companies of Boston. He believed neither of these bodies had taken any part in the discussion of this matter at all. Inasmuch as the Underwriters' Laboratories is now itself discussing this whole matter (and when it has decided on the dimensions, those dimensions will have to be produced by the manufacturers whether they like it or not), he thought it better to get from them some sort of coöperation in this matter before the report itself is finally submitted as an accomplished fact.

He desired to make a motion (which was an amendment to a previous motion by Mr. Child and accepted by him) that the committee be continued and that the presentation of this report be deferred until the Spring Meeting, in the hope of securing from every one concerned a substantial agreement of opinion.

He called attention to the point that if the report is approved by this present meeting it will have the effect of scattering standards instead of adhering to a standard; that is, the people who use these materials will not be adhering to any particular standard. In the interests of common sense the thing should not be decided at this moment until further conference is had.

The motion by Mr. Rockwood was seconded by William Kent and carried by a rising vote.

THE ANNUAL MEETING

THE thirty-fourth Annual Meeting, held December 2 to 5, was one of the largest in the history of the Society, with a total registration of 1271, of which 778 were members. Following the plan of the last two years, the professional sessions were to a considerable extent in charge of sub-committees appointed by the Committee on Meetings, with the result that there were several symposiums on widely diversified subjects which gave a very broad scope to the meeting. The chief social event was the German Dinner on Thursday evening, planned to give those who were not of the party visiting Germany last summer an idea of the hospitality and unusual privileges shown the visitors, as well as to make an enjoyable reunion for those who spent the time together during the trip. Of very unusual interest, also, was the lecture by John W. Lieb, Jr., on the life and accomplishments of Leonardo da Vinci—one of the most remarkable lectures ever listened to by those in attendance at an annual meeting.

Another interesting social feature of the meeting was the tea and musicale given in the Society rooms on Wednesday afternoon under the auspices of the Ladies Reception Committee, Mrs. Edward Van Winkle, Chairman. This attracted a large attendance of members and guests.

An innovation was made this year in the holding on Friday evening of reunions of the engineering alumni of various colleges, which proved so successful that it will doubtless be made a permanent feature.

OPENING SESSION, TUESDAY EVENING

As usual, the meeting began on Tuesday evening in the auditorium of the Engineering Societies Building, with the President's address, delivered this year by Dr. W. F. M. Goss, on Education as a Feature in the Development of Professional Ideals, which is published in full in this number of The Journal.

Following the address Dr. Goss read the report of the tellers of election of officers, when the following results of the ballots cast were given: President, James Hartness; Vice-Presidents, Henry L. Gantt, E. E. Keller, H. G. Reist; Managers, A. M. Greene, Jr., John Hunter, Elliott H. Whitlock; Treasurer, Wm. H. Wiley.

The President-Elect, James Hartness, was next escorted to the platform, where he was received by the retiring President, who in introducing him referred to his broad experience in the field of industrial activity, his wide acquaintance among engineers, and his fine qualities as a man. Mr. Hartness in reply briefly expressed his realization of the responsibilities and high honor attached to the office of President of the Society, and his desire to give his best energies in furthering its interests.

WEDNESDAY MORNING SESSION

At the annual business meeting on Wednesday morning the reports of the Council and the Standing Committees were first presented. The former have already been published in The Journal, and the report of the Council will appear in Volume 35 of Transactions.

As a part of the required procedure, the proposed amendments to the Constitution, C-9 and C-11, were read. These specify more strict requirements for the grades of member and associate-member, raising the age requirement for the former to thirty-two years, and of the latter to twenty-seven years. A student rarely graduates from a technical school until the age of twenty-two, and under the new limits he will have at least ten years practice in his profession before qualifying for the grade of member, and five years for associate-member.

The next business in order was the report on Standard Threads for Hose Couplings offered at the request of the Sub-Committee on Fire Protection. This came as a result of the paper on this subject at the Spring Meeting by F. M. Griswold, who through consistent work for many years has secured the adoption of a standard by various organizations. The report advocates as a standard for 2½-in. hose connections a diameter of $3\,^{1}/_{16}$ in. over the thread with 7½ threads to the inch, this being an intermediary of designs in most general use, and thus allowing the greatest possible interchangeability of hose connections. Standards are recommended for other sizes also, and sample couplings to show the various standards were given to the Society as a present from the Committee. This report was accepted.

Following this, the Committee on the Standardization of Pipe Thread Gages presented a report, which was accepted.

Then followed a long discussion of a report by the Committee on the Standardization of Flanges. An abstract of this report, and the discussion which followed, appear in another section of this issue of The Journal.

At the last Spring Meeting a report was presented as a result of the united work of the committee of this Society on the standardization of flanges and that of the National Association of Master Steam and Hot Water Fitters, advocating what was called "the 1912 U. S. Standard."

Since that time the Committee of The American Society of Mechanical Engineers through conferences with the Manufacturers' Committee have worked out certain modifications of the previous report and extended the sizes. The new report is in the nature of a compromise in which engineering features relating to strength and safety are maintained, but with concessions in regard to interchangeability of fittings. Objections to the report were raised by several members of the Master Steam and Hot Water Fitters Association during the discussion. Upon motion of George I. Rockwood it was voted to present the matter for further discussion at the Spring Meeting with a view to bringing as many elements as possible into accord in the interim.

After this discussion the Increase of Membership Committee presented its report, which also appears in this issue of The Journal. This shows that 1046 applications for membership were made during the past fiscal year, which is $33\,^{1}/_{3}$ per cent more than for the year previous. A pleasing event in connection with the subject of membership was the introduction of Amos Whitney of Hartford, Connecticut, eighty-one years old, who had just become a member. Worcester R. Warner spoke feelingly of having been one of

Mr. Whitney's boys forty-five years ago, and of having graduated from the "Pratt and Whitney University."

The discussion of these various reports concluded the business meeting.

PROFESSIONAL SESSIONS

So much time was required for the discussion during the business session of Wednesday morning that the discussion of the first paper of the professional session which followed was only partially completed at the time for adjournment. This, together with the other papers scheduled, was carried over until the session on Thursday morning. Otherwise the program was carried out as intended. The arrangement was such that Thursday afternoon was left free for excursions, and on Wednesday afternoon and Thursday morning there were several simultaneous excursions, all of them well attended and successful.

Following is the list of papers included for the meeting:

Notes on the Further Operation of Large Boilers of the Detroit Edison Company, J. W. Parker
Task Setting for Firemen and Maintaining High Efficiency in Boiler Plants, Walter N. Polakov
The Properties of Steam, R. C. H. Heck
Report of Sub-Committee on Hoisting and Conveying
Dynamic Braking for Coal and Ore-Handling Machinery, Clark T. Henderson
Steel Underframe Box Cars, George W. Rink
Steel Upper Frame Box Cars, R. W. Burnett
Cotton Conveying Systems; their Safeguards Against Fire, H. A. Burnham
Specifications for Factory Timbers, F. J. Hoxie
Textile Cost Accounting, C. B. Arnett and C. F. Cunningham
Efficiency of Rope Driving as a Means of Power Transmission, E. H. Ahara
Comparative Tests of Three Types of Lineshaft Bearings, Carl C. Thomas, E. R. Maurer and L. E. Kelso
Pitot Tubes for Gas Measurement, W. C. Rowse
Tests of Vacuum Cleaning Systems, J. R. McColl
Tests upon the Transmission of Heat in Vacuum Evaporators, E. W. Kerr
The Art of Enameling or the Coating of Steel and Iron with Glass, Raymond F. Nailler
Gears for Machine-Tool Drives, John Parker
Cast-Iron for Machine-Tool Parts, Henry M. Wood
A Record of Pressed Fits, C. F. MacGill
Standardizing Machinery, Fred H. Colvin
A New Process of Cleaning Producer Gas, H. F. Smith
Present Status of the Large Gas Engine in Europe, Prof. P. Langer
The Fire Hazard in Turbo-Generators, G. S. Lawler
Extinguishing of Fires in Oils and Volatile Liquids, Edw. A. Barrier
Control of Automatic Sprinkler Valves, Fred J. Miller
The Need of More Care in the Design and Construction of Elevated Tanks, W. O. Teague
Fire Pumps, Ezra E. Clark

WEDNESDAY EVENING

At its meeting in Leipzig last June, the Verein deutscher Ingenieure voted to confer upon George Westinghouse, Past-President of the Society, the Grashof Medal, the highest distinction within its power to grant. Its safe delivery to Mr. Westinghouse was entrusted to the Society, and this trust was formally discharged at the session of Wednesday evening, December 3, in the presence of a large audience. Mr. Westinghouse was unfortunately prevented by illness from attending, and the medal was received for him by James Hartness, President-elect.

The Grashof Medal was founded by the Verein in memory of Franz Grashof, and is granted to men who have rendered prominent service in the field of engineering by scientific work or practical activities. Mr. Westinghouse is the third engineer outside of Germany and the first in America to be thus honored. In making the announcement of the award at the Leipzig meeting, Dr. von Miller, president of the Verein, drew attention to the fact that it was not made to Mr. Westinghouse because of the presence of the American Society at the joint meeting, but because of his services for the good of humanity. He spoke also of Mr. Westinghouse's remarkable achievements, the invention of the air-brake, the development of the alternating-current system, and his successful introduction of the geared steam turbine for marine propulsion.

A committee of its members was appointed by the Verein to attend the presentation ceremony on Wednesday evening, consisting of Geheimrath Romberg of Cologne, Herr G. D. Waetzoldt of the German consulate, Col. E. D. Meier, Henry Hess, and Dr. Rudolph Hering; and the three American sister societies, which had been invited to participate, were respectively represented by Charles Warren Hunt, Secretary, Am.Soc.C.E., C. O. Mailloux, President, Am. Inst.E.E., and A. R. Ledoux, Past-President, Am.Inst.M.E.

The meeting was called to order by President W. F. M. Goss, who spoke of the honor conferred upon the American engineering profession in the award to Mr. Westinghouse, and called upon Col. E. D. Meier to give some account of its presentation. Col. Meier described the presentation of the medal at the Leipzig meeting in the presence of a brilliant assemblage, including the King of Saxony and his court, and read a number of cablegrams of greeting and congratulation to Mr. Westinghouse and to the Society.

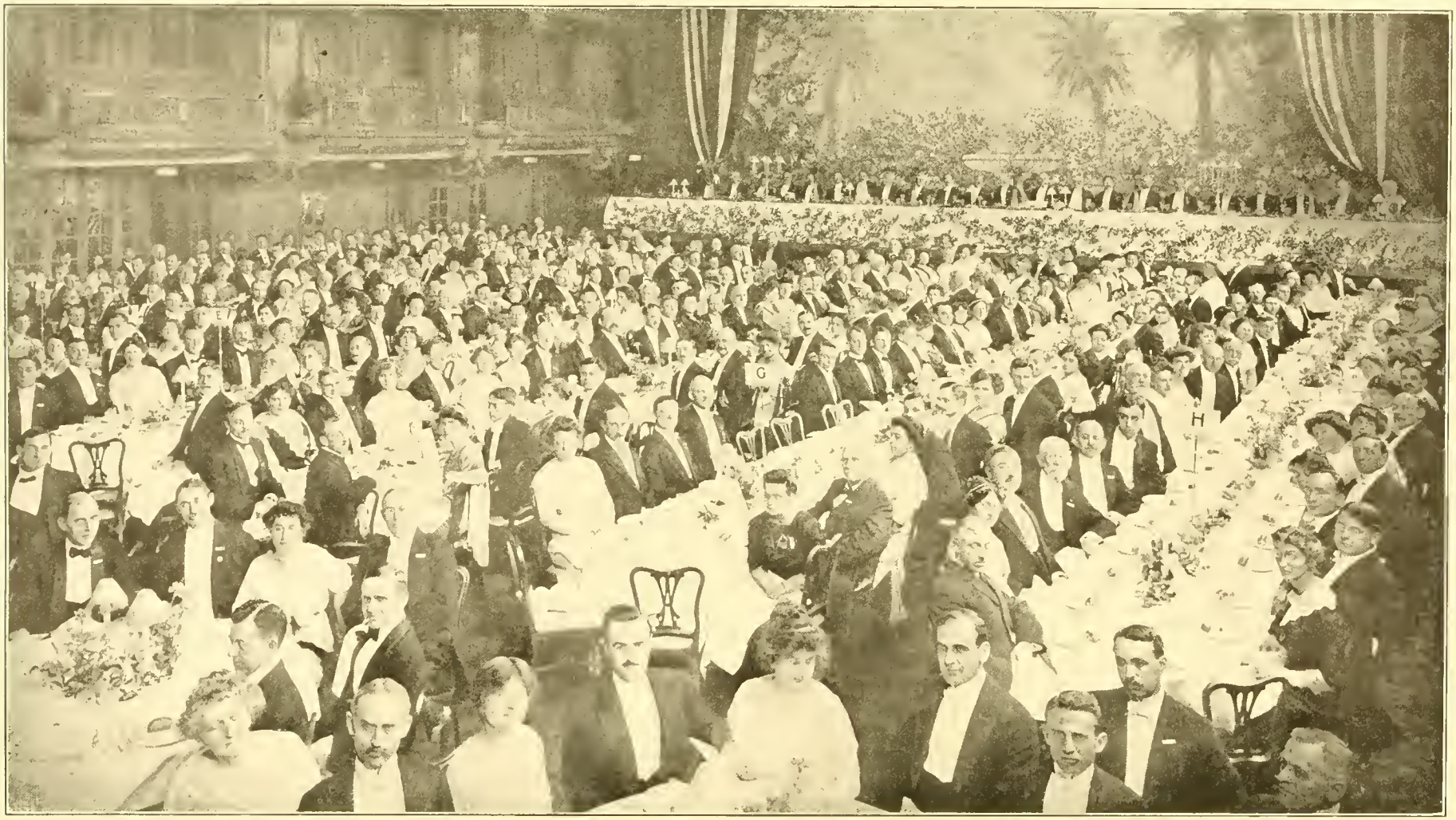
Geheimrath Romberg, acting as spokesman of the Verein, then addressed the audience in German, emphasizing the importance of international meetings among members of the same profession, as a means of bringing nations closer together in a mutual understanding of one another's problems. The Grashof Medal, he said, had been instituted in memory of a man prominent as an engineer, educator and writer, and those to whom it has been granted form a group which it is certainly an honor to belong to.

THURSDAY EVENING'S ENTERTAINMENT

On Thursday evening a German Dinner was held in the Grand Ball Room of the Hotel Astor as one of the features of the usual social evening which has become an institution of the Annual Meeting. Prof. L. P. Breckenridge was the toastmaster of the evening, and the speeches were interspersed between the courses as is the custom in Germany. He was introduced by President Goss, who in turn introduced President-elect Hartness, who gave the results of his observation of industrial Germany, and emphasized the need in this country of greater specialization in our large manufacturing plants.

Col. E. D. Meier explained how the German trip had its inception in the visit of the German engineers who came here three years ago in the interests of the German Museum at Munich. Prof. Arthur M. Greene, Jr., spoke of German education, and said that the researches conducted by the German technical schools had been of great value to the profession largely because of the opportunity afforded for their publication by the Zeitschrift of the Verein deutscher Ingenieure. He was glad to know that through the development of the new Journal of this Society there might eventually be a similar opportunity. Remarks were also made by Sir George Croydon Marks, M.P.

H. L. Gantt said that the German engineer had reached the point which Professor Sweet hoped we some day would reach, for he already realized that the man who knows "what to do and how to do it" is not only the equal but the superior of the man who knows "what was done and who did it."



Group of Members and Guests at the German Dinner held in the Hotel Astor, Thursday Evening, December 4

The menu and arrangement of the tables at the dinner were almost an exact duplicate of the dinner given in Germany at the Zoological Park in Berlin. The decorations of the ballroom were in German and American national colors, and the arrangement of the speakers' table on the stage was as nearly as possible like the plan used during the entertainment of the American party at Düsseldorf. The background of the stage showed the interior of a conservatory of palms, and was intended to remind the diners of the somewhat similar dinner given in the Palm Garden at Frankfort.

Seated on the speakers' platform were (from left to right): E. E. Keller, Oberlin Smith, Henry R. Towne, Rudolph Hering, H. G. Reist, Calvin W. Rice, A. M. Greene, Jr., Frederick R. Hutton, E. D. Meier, James Hartness, President-elect, W. F. M. Goss, President, L. P. Breckenridge, Worcester R. Warner, Sir George Croydon Marks, M.P., H. T. Clifford, Alex. C. Humphreys, Henry L. Gantt, Henry Hess, Privy-Councillor Fr. Romberg, James Mapes Dodge, William Kent, Samuel T. Wellman

He hoped that more of our industrial work could be accomplished in this spirit and by scientifically educated men as it is done in Germany.

Prof. H. E. Clifford showed himself a true genius both by dodging the subject assigned to him by the toastmaster, and by "talking back" to the toastmaster in poetical phrases akin to Kipling and Longfellow. The last toast of the evening, "The Ladies," was given by Secretary Rice.

Something that was appreciated by everyone was the collection of cablegrams read from the various sections of the Verein deutscher Ingenieure at Hamburg, Dresden, Leipzig, Düsseldorf, and Mannheim; from Doctor von Miller, President of the Verein; from the German Museum at Munich; and from Professor Matschoss, who did so much in conducting the party through Germany.

A vivid account of the German trip was given by Worcester R. Warner following the dinner, in which a large number of lantern slides made up from kodak pictures taken by members when abroad and from photographs of historic buildings were used. There were 499 in attendance at the dinner, and over 100 came in later to listen to the lecture, which all greatly enjoyed, and to join in the dance and social time which concluded the evening.

EXCURSIONS

A number of interesting excursions were provided for by the Excursion Committee, John J. Swan, Chairman. An Information Bureau was maintained throughout the meeting and guides appointed to conduct parties to points of general interest, and in addition a number of plants were thrown open, which were extensively visited.

Through the courtesy of the engineering department of the Board of Water Supply, an opportunity was afforded for a visit to two of the shafts and power plants for the tunnel construction work on the Catskill Aqueduct in New York City. Shaft No. 9, at 150th Street and St. Nicholas Avenue, was visited first, and Roger Armstrong, section engineer, and Michael Quinn, superintendent of the Pittsburgh Contracting Company, addressed the party on the engineering features involved and the equipment and methods of excavation. After examining the surface equipment, the party descended into the tunnel and viewed the south heading where the last rock between it and the tunnel to the south had been removed that day. While in that heading, a blast at shaft No. 11, two miles to the south, was clearly felt by the party, and before they left the tunnel the smoke of the blast came upon them, giving them some idea of the conditions under which actual tunnel operations are pursued. The underground magazine for the storage of 1000 lb. of explosives was also shown to the party. The party then proceeded to shaft No. 12, at 106th Street and Central Park West, where an opportunity was had to view the finished tunnel work, the concrete invert having been completed in the south tunnel. The party was conducted by John R. Healy. A group of the membership also visited the Kensico Dam in Valhalla, which is now approaching completion, under the guidance of F. v. D. Longacre.

A visit to the new Woolworth building, the highest office building in the world, was attended by about forty members and guests. By permission of E. A. Cochran, superintendent of the building, the entire power and mechanical plant of the building was thrown open for inspection and much interest was manifested in the elevators and their safety appliances, the fire protection and water supply system, which owing to the height of the building is divided into several levels, the highest imposing a pressure of over 300 lb. on the pumps; and the elevator equipment, where the traction type of elevator machines of the Otis Elevator Company are used, which are especially adapted for high-rise service. There are 26 passenger elevators of this type installed in the building, two of which rise to the 51st story of the tower, a rise of 679 ft., the highest travel for a building elevator in the world. Furthermore, the six express elevators operating in the tower, are the highest speed building elevators in existence, being designed to operate at a speed of 700 ft. per minute. These elevators are protected from danger in falling by the air cushion method, the lower portion of each shaft being enclosed and heavily strengthened to serve as an air cushion. The party was guided by H. R. Cobleigh.

The opportunity for an inspection of the new Grand Central Terminal of the New York Central and Hudson River Railroad attracted a large number, and through the courtesy of Geo. W. Kittridge, Chief Engineer, guides were appointed who conducted this party through the new passenger station, the yards, the heating plant, and the lighting sub-station, and explained the operating details of the new terminal. For the complete presentation of the many interesting details of the great terminal, a 16-page pamphlet, entitled The Mechanical, Electrical, and Sanitary Equipment of the Grand Central Terminal, had been prepared especially for this convention and was distributed to the members of the party and at the meetings. The party was conducted by Carl Schwartz.

The arrangements made by the Hamburg-American Line for an inspection of the second largest vessel of its fleet, the Kaiserin Augusta Victoria, next in size to the Imperator, were taken advantage of by about 70. The party was taken throughout the ship from the captain's bridge down to the steerage and stoke hole, including a visit to the engine room, and was conducted by Alfred E. Kornfeld.

A party of about 200 visited the United States Navy Yard in Brooklyn, under the guidance of J. J. Swan. Commander Hardy, assisted by other officers, conducted the visitors throughout the shops and yard, and through the courtesy of O. P. Jackson, Commander U. S. N., and Chief Engineer Fisher, of the battleship, the party were allowed to inspect the U. S. S. North Dakota, which is representative of the latest construction in modern battleships.

The following plants were also visited: the high-pressure pumping stations of the City of New York; the Waterside stations of the New York Edison, W. W. Macon, guide; the 59th Street power station of the Interborough Rapid Transit Company, Alfred Noble, guide; the E. W. Bliss Company, Brooklyn, H. G. Goss, guide; the hydraulic works of Henry R. Worthington, Harrison, N. J., H. G. Goss, guide; the paper mill of the Tidewater Paper Company, Brooklyn, W. W. Macon, guide; and the Davis-Bournonville Company, Jersey City, N. J., N. B. Payne, guide. The two latter plants were visited for the first time at an annual meeting. At the Tidewater Company the manufacture of newspaper stock from pulp to finished paper was shown, and at the Davis-Bournonville plant the visitors had the opportunity of seeing the rebuilding of a broken tooth in a gear wheel, a demonstration of fire emergency equipment, and the cutting through of a section of armor plate with the oxyhydric torch, and other interesting exhibits.

EFFICIENCY IN TECHNICAL EDUCATION A FACTOR IN THE DEVELOPMENT OF PROFESSIONAL IDEALS

BY W. F. M. GOSS, CHICAGO, ILL.

President of the Society

FIFTY-ONE years ago, the Congress of the United States passed an act providing for the establishment of colleges in each of the several states of the Union.[1] The passage of this so-called Land Grant Act, more than any other single event, constitutes the foundation of technical education in the United States. It aided in the establishment of the Massachusetts Institute of Technology, of Cornell University, and in due time of colleges or universities offering engineering courses in every state. Many states were slow in proceeding under this act and some, which to-day have flourishing universities, had not then been admitted into the Union. As a consequence, technical education, as a national movement, did not have its beginning until the early seventies, or approximately forty years ago.[2]

The coming of the technical school, whether as a department of the state university or otherwise, was not in any large sense the result of active interest on the part of engineers. It came as the unfolding of an educational movement inspired and sustained by scientists and educators.[3] It came as an expression of a nation's desire to emphasize the importance of science in its relation to the every day work of mankind. It came when our country's engineering industries were young, when engineering practice was guided by precedent rather than by mathematical analyses, and when those who were skilled in leadership were also skilled in the manipulative processes of their art. It came when the industries offered few inducements to a young man whose chief claim to their attention was the fact that he had studied books, and when the limitations of the employer often made it difficult for him to appreciate the qualifications of such an applicant. The practical men, therefore, expected the new school to train its students in practice rather than in theory, to do things rather than to know facts; they looked to the school for a preparation which should be kinetic rather than potential.

The technical school was not unsympathetic to this expectation. It gave early evidence of a desire to meet the reasonable demands of those to whom its graduates must go. It gave generous attention to courses in shop practice, in field work, in drawing, and in designing. It introduced certain text-book courses, largely descriptive, and in many other ways it emphasized the more practical aspects of the engineer's work. By so doing, the school met an immediate need, gained for technical education the good will of the leaders of industry, and laid the foundations for a degree of popular support, which, in process of time, transformed the simpler beginnings of nearly half a century ago into one of the world's greatest undertakings in higher education.

But, in giving their response to the immediate needs of the industries, the early leaders in technical education rarely lost sight of the possibilities of science as a means to the development of correct theory. Under the guidance of such men as Rogers, Runkle and Thurston, the art of the teacher was so combined with processes common to practice, that even training in practical things became an important educational influence. Shop courses and drawing courses became new expressions of an educational function. The study of things practical was put upon so high a plane that the attention of the student was secured, his power of observation increased, his view broadened and all his conceptions stimulated. Moreover, while admitting courses of a practical nature, the early leaders in technical education did not limit their scheme of instruction to such courses. They construed the federal law liberally. They utilized the popular interest in more simple applications of science as an argument for the encouragement of work in more complex fields, and, as the usefulness of the men trained under these leaders became more and more apparent, an extension of their plan of work became possible. Courses of

[1] This "Land Grant Act," sometimes referred to as the "Morrill Bill," in honor of Representative, and afterwards, Senator Justin S. Morrill, of Vermont, who labored through several sessions of Congress to secure its passage, was signed by Abraham Lincoln, July 2, 1862. It granted to each state in the Union 30,000 acres of land for each senator and representative to which it was entitled in the Federal Congress, for the purpose of promoting "the liberal and practical education of the industrial classes in the several pursuits and professions in life." It has recently been referred to by a distinguished educator as "the greatest endowment of higher education ever made at one time by the act of any legislature."

[2] This statement does not disregard the fact that engineering education under private auspices began earlier than indicated. The Rensselaer Polytechnic Institute was founded in 1824, incorporated in 1826, and reorganized under its present name in 1849.

[3] In connection with this statement it will be of interest to note that President Edmund J. James of the University of Illinois, in a paper entitled "The Origin of the Land Grant Act of 1862," has shown that Jonathan B. Turner, at one time professor in Illinois College at Jacksonville, Ill., deserves the credit of having been the first to formulate clearly and definitely the plans of a national grant of land to each state in the Union, for the promotion of agriculture and the mechanical arts, and of having organized and continued to a successful issue, the agitation that made possible the passage of the bill.

Presented at the Annual Meeting, New York 1913, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

instruction were extended. Descriptive work gradually gave way to work which was more mathematical. Great laboratories for instruction and research were established, until the American student finds at home educational facilities for which he formerly went abroad.

Meanwhile the every-day citizen, who is the normal supporter of the great state university, is coming to understand something of the breadth of the educational problem which is presented by the activities of the technical school. He has seen the number of its students multiply, and its graduates become leaders in the work of great industries. Questions affecting the support of the technical school have sometimes appeared as political questions, and in his discussions of these the normal citizen has not been found lacking in his appreciation of the technical school. Engineering education now suggests something more to him than a class-room. He understands that efficient instruction must find expression in the applications of science and in the promotion of scientific research. These are important conceptions, and the fact that they are entertained by the public suggests the great influence already exerted by the technical school.

The American technical school stands today on the threshold of great achievements. Its pioneer days are nearly over. The fruitage of two generations of educational effort is now in evidence. Captains of industry no longer look in doubt upon the technical graduate; they give him work. Public confidence in the new education has been won and its permanent support is assured. What of the future? To what new attributes must the technical school give expression and what new responsibilities should it assume? These are questions which today confront the school, and they are questions also in which the membership of The American Society of Mechanical Engineers may well be interested, for the technical school and the professional society are partners in a common cause.

An attempt to outline the problems of the technical school must recognize the fact that great advances in any art or profession await the coming of great men. The modern need in the field of engineering is for men who can perform the exceptional task; for men who are safe keepers of their brothers' interests; for men whose qualities of character are so sound and strong that they instinctively perceive the way of truth and follow it; for men whose activity and understanding detect the defects in established practice and find a way to improve that practice; for men who so well understand the fundamental principles of science as to be able to predict the effect of the next step before it has been taken; for men, in fine, who can rank with the world's great leaders in science and industry. I conceive it to be the prime purpose of the technical school to make its contribution toward the development of such men.

It would seem unnecessary to remind an audience of professional engineers that the achievements of the technical school center in the quality and strength of its instructional staff. The present-day need is for increased strength of staff. All honor is due the fine coterie of men who, undertaking the work of the technical school a quarter of a century or more ago, have adhered to their task in the face of discouragement at great personal sacrifice and with a spirit that has been fine and even heroic. But retrospect, however satisfactory in itself, will not solve our future problems. Great leaders in the work of the technical school are few, and the unfortunate fact is that throughout the years that are past few men have been in training where the service now demands many. There are many reasons for this. An important one is to be found in the limitations which have been put upon the salary budget. The man who builds great bridges or who directs the activities of a great industry, is none too gifted to guide the efforts of ambitious youth, and hold before the student large ideals of life. And yet, in the industries a man may receive in a month an amount equivalent to the annual salary of many college professors. It is clear to all who know the field that while the school must suffer some years to come, through its deficiencies in the past, a new policy should be entered upon as speedily as possible. It should be expressed in such terms as will convince the exceptional man, looking for a career, that it will be worth his while to prepare himself by study, by professional practice, by travel, by activities as a scientific investigator, by every process which can develop and broaden, for a life-work as a member of a college faculty. Few among American technical schools can today offer professorships which in themselves are sufficiently attractive to justify a young man in securing for himself so elaborate a preparation. The remedy cannot ordinarily be applied by the college itself; it must come as the result of interest shown at the sources of financial supply. In the great state universities it must be the result of public appreciation of the need; you, I know, will realize that public appreciation, though a plant of slow growth, may be cultivated by many different agencies.

Not only is it required in the interest of higher efficiency that the American technical school have an instructional staff of the highest possible quality, but it is also required that such a staff be not overburdened with routine duties. The American youth is greatly influenced by the personality of his instructor. While the exceptional student will view his problems broadly, will add his own personality to that which the professor gives and thus work out large and vigorous conceptions, the normal student is as a disciple following a master; he admires the master's skill, he thinks in terms of the master's thoughts and is very likely to be influenced by the master's limitations. If the engineering graduate sometimes degenerates into an animated slide rule, may it not be possible that he has been instinctively led to such a career through ill-conceived

tread-mill processes in the class-room? If so, the remedy is to be found in reforming the work of the class-room, and one sure road to such a reform is that which opens the way whereby men of large caliber may have time in which to impress themselves upon their students. The technical school is greatly in need of simple living and high thinking. Simple living is easily attained unto, but high thinking, in its essence, involves a certain element of leisure, or perhaps freedom in the choice of one's occupation, which after all, is but another term for leisure, and no atmosphere surcharged with high thinking can prevail on a campus where every individual student and professor is perpetually keyed up to concert pitch in an endeavor to accomplish an assigned task. This is a matter in which our English and German neighbors can, by the trend of their procedure, disclose much which will be serviceable to the American technical school.

The importance of superior leadership in the school is emphasized by the fact that the attitude of the American student reflects rather faithfully the changing spirit of the times. His parents in their home, though perhaps living unpretentiously, no longer pursue the quiet and simple ways of former days. They have their part in the complexity of the modern business and social life. It is not surprising that their son, the student of today, finds some difficulty in settling down to the quiet routine of the cloister. He is more likely to combine with study the social and athletic activities of the college. The encouragement of fellowship with men, as well as of study, is in fact recognized by the school authorities as a legitimate function of the university. The danger appears in a disposition on the part of students to segregate their activities, to regard their study as work and their athletics as play. Comparisons growing out of such distinctions are to the disadvantage of the student's occupation. The habit of placing the emphasis continually on the joy of the play, prevents him from feeling the joy of the more intellectual pursuits and it encourages half-hearted study. It is here that masterful leadership in the classroom will assert itself. The joy of scholastic achievement is best made plain by the introduction and maintenance of inspiring views depicting the meaning of a life of service coupled with the conception that student days are part of such a life; that student days are not merely a preparation for life, but that they are life.

Masterful leadership eliminates entirely the feeling once entertained by the students, that the instructor is a taskmaster, and that to be obedient to him, the student must perform the task. The great teacher, freed from the burden of excessive routine, may easily recognize differences in ability and will encourage the student who must plod and inspire to unusual performance the brilliant student who knows no limit to his achievement save his physical strength.

Assuming the technical school to be in possession of an ideal instructional staff, the way will open for progress through many channels of secondary importance. It is altogether possible that in our present-day routine too much time is given to things which are simple. Much that is now studied may perhaps be read. The habit of studying intensely a few books to the entire exclusion of the great mass of historical and biographical engineering literature affords the student but little opportunity of acquiring a habit of rapid and intelligent reading, which in itself is an accomplishment worth striving for. The practice of the shop laboratory, the drawing-room, the surveying field and the study of descriptive texts, rightly interpreted, are important adjuncts in the training of the engineer, but the time has ceased to be when such activities constitute the chief characteristics of the technical school. Year by year the technical school has increased the emphasis given to processes which are mathematical. The progress of the next decade will be seen in the thoroughness with which high standards in such work are accepted and advanced. The intensive work of the course must be based upon fundamental theory, and the fields to which such theory is applied must be broadened. The engineering graduate is no longer required to be prepared to operate machines, but he must have a well-trained mind and he must possess power to perfect his qualifications along any specialized lines in the shortest possible time. To this end, the years in college must be spent in acquiring an understanding of principles and in the development of those aspects of theory which are difficult to acquire after one's college days are over.

The aspirations of many students will not be satisfied by the possibilities of a four years' course, and for these graduate work must follow. In making this assertion I do not forget that in this country graduate work in engineering has thus far received but little attention, but this is due rather to our immaturity than to the fact that we do not recognize its need. The time is at hand when the services of the scholarly engineer, the man who through his perfect command of fundamental theory can visualize a cause from its effects, will be in great demand. The manufacturing industries, the great commercial laboratories of our country and the colleges themselves are in need of men who have done more work than any one can accomplish in the normal four years of a college course. The problem of graduate work in engineering is therefore a national one, and it is worthy of note that a number of universities and technical schools are now holding before the public visions of its value.

The American technical school has already accomplished much in the development of laboratories. While it has used them thus far chiefly as facilities for instruction, it has always recognized the fact that there are other and equally important functions to be performed by them. The laboratories of a considerable number of schools have made important contributions

to the sum of human knowledge. This fact is suggestive of future possibilities. The practice of men must be guided by facts. The technical school cannot content itself with routine service. It must enshroud its classroom and its laboratories with an atmosphere of scientific achievement; its professors should be leaders not only as classroom instructors, but nation-wide leaders, even world-wide leaders in the complex and highly diversified fields of the science which they represent. The laboratories available for the use of such men should multiply. Every technical school should aid, as individual schools have already aided, in setting forth new interpretations of physical phenomena. The laboratory must be more than a shop, more than an engine room, more than a collection of testing machines. No great laboratory can be ordered ready-made. It cannot be produced in response to a decree. Whatever its dimensions or its cost, it can be great only in so far as it reflects a purpose which is scientifically sound, and employs means which are scientifically correct. Its significance is necessarily limited to the qualities of the men who create and operate it. A laboratory which has been evolved through the activities and desires of a master is not only priceless for the school that possesses it, but necessary as a source of information of the highest value, to the field of practice which it is designed to serve. The chief engineer of a great railway system, in writing of the work of a certain college laboratory, has recently certified in terms which are clear and emphatic, to the value of principles affecting the design of certain structures which had been developed by the laboratory and extensively used by the corporation which he served. Illustrations of similar import will occur to all readers of technical literature. Assuming that the country has need of research laboratories for purposes quite apart from the work of instruction, it can, I think, be shown that the technical school constitutes the most promising agency in our national economy upon which to place the responsibilities incident to their creation and maintenance.

In concluding this phase of my discussion, I must not fail to recognize the contributions of members of this Society to the upbuilding of the American technical school. I do not forget that some of our members are university, college or technical school professors; that others are presidents, and still others are officers or members of administrative boards. They will readily understand, however imperfect my language, the significance of the matters which I am endeavoring to emphasize. To those of you who have a lay interest only in technical education, let me suggest that you do not always time your visits to your Alma Mater to make connection with a great football game or a great baseball game, but that you make some visits at a time when you can show interest in the academical progress of the student body; not because the game is unworthy, but that you may secure some understanding of the students' achievements in severely scholarly efforts, which after all is the measure by which the success of the school must ultimately be judged.

The relation existing between the standard of instruction in schools which prepare for a profession and the ideals of the profession have already been suggested and in their general aspects are obvious. The fact that educational institutions of high standing are sending out each year into the engineering pursuits of our country more than 2500 graduates, nearly 1000 of whom enter the field of mechanical engineering, suggests the basis for this relationship. The technical school is, in fact, recruiting and otherwise stimulating the engineering work of the country. Its more important contributions may be summarized as follows:

First, the work of the school tends to emphasize the dignity of the calling. Professionalism as distinguished from the art or practice of engineering is after all a question of quality. Professionalism is breadth! In our ambition to have a large part in the world's affairs we sometimes forget the fundamental source of power. We sometimes think too much of honors and too little of service; we desire the position before we are qualified to discharge the responsibilities it imposes. Our strivings must be for fitness. Progress in advancing the ideals of our profession will depend upon the character of the service rendered by the members of the profession. If every practitioner in the field of Mechanical Engineering possessed character and ability responding to our highest ideals, no one would question the right of mechanical engineers to regard themselves members of a profession. The technical school makes its contribution to the upbuilding of professional ideals by sending trained men into the profession.

Second, a service which the technical school is rendering the profession of engineering is that of contributing to the sum of its scientific data. Engineering as a science has made progress by leaps and bounds; rule of the thumb has given way to the rule of the mathematician. But notwithstanding all that has been accomplished in his direction, there are as yet but few departments in the field of mechanical engineering in which the basis of design is actually perfected. Further progress awaits the establishment of facts concerning such matters as the behavior of constructive materials, of lubricating films, of combustible mixtures, and of liquids and gases employed in thermo-dynamic processes as vehicles for the transmission of heat. The American engineer who has hitherto been occupied with the so-called practical aspects of his profession has concerned himself less than have the engineers of the great empire across the sea, with the work of the scientist. We, as engineers, need to train ourselves to a condition of mind which will make studious processes less difficult than at present. Along this line of endeavor the researches of the technical school will aid the profession by establishing new standards of pro-

ficiency, and by making new contributions to the existing fabric of facts.

Third, an important contribution which the school is rendering the profession of engineering is that of emphasizing the profession's unity of purpose. The college graduate has had at least four years' training in teamwork. A majority of the student organizations with which he has been associated has maintained extra-mural affiliations. The college fraternity, the college Y. M. C. A., the college athletic activities would lose much of their significance if their whole thought and action were restricted to the home campus. In intercollegiate contests the desire is not in any large sense to win over a neighbor, but to win as an achievement. A graduate of Wisconsin finds a friend when he meets for the first time a graduate of Illinois, and a member of the faculty of one institution, upon a trip of visitation to a neighboring institution, is sure to find himself among those who cheer and stimulate him. This intercollegiate spirit of fellowship has become a national asset—it persists when the day of graduation has passed. It represents a spirit which, in the business and professional world, conserves and upbuilds. It is working out the world's great problems of mutual respect, of mutual help and of concentration of purpose. In the development of our future ideals and practices, tradition and prejudice are likely to play a steadily diminishing part, and the spirit of fellowship, inherited from college days, a part of steadily increasing importance.

Whatever may be the nature of the contribution of the technical school to the ideals of the profession, the extent of the contribution is a function of the quality of the school. Better instruction in the school must supply better recruits for the profession, greater activities in scientific researches on the part of the school must operate to increase the facility with which the problems of the engineer are solved, and influences in the school which tend to extend the student's horizon and broaden his sympathies, will in due time make their impress upon the professional life outside of the school. That is, efficiency in technical education is a factor in the development of professional ideals, and hence a matter of prime importance to this society, as well as to all other organizations of engineers. I have presented this discussion because I believe that the problems of the technical school should not be left to the school master, for, broadly interpreted, they are not the problems of the school but the problems of the profession. As such they should, I believe, receive painstaking and persistent attention from this and other engineering societies.

The Grashof Medal presented to George Westinghouse by the Verein deutscher Ingenieure at Leipzig, June 1913, and formally transmitted to Mr. Westinghouse by The American Society of Mechanical Engineers at the Annual Meeting, December 3, 1913

TEXTILE SESSION

PAPERS CONTRIBUTED AT THE ANNUAL MEETING BY THE SUB-COMMITTEE ON TEXTILES

COTTON CONVEYING SYSTEMS: THEIR SAFEGUARDS AGAINST FIRE

By H. A. Burnham, Waltham, Mass.

Member of the Society

The purpose of this paper is to describe briefly methods of limiting the number and extent of fires such as occur from known causes in cotton mills in connection with the preparing processes of opening and picking. Such fires form from 50 to 75 per cent. of all the cotton mill fires reported. The particular point in these processes to which attention is directed is the mechanical arrangement of the conveying apparatus used for transferring the cotton from the bale opening room to the picker room.

The methods described are the results of the experience of many of the best known cotton mills in the northern and southern states, whose co-operation with the Associated Factory Mutual Fire Insurance Companies has been instrumental in developing this class of apparatus along the present lines of greatest safety and efficiency. There are records of many instances in which, by the observance of the simple precautions described, troubles from fire formerly occurring with great frequency and regularity have almost entirely disappeared.

The usual machinery for the above work consists of:

a A bale breaker or opening machine having a spiked apron moving at moderate speed at the rear of a square iron hopper, which is fed by hand or by a mixing apron with lumps of cotton from the bale. This machine loosens up the matted cotton, allowing any heavy foreign substance to drop out, and delivers the loose cotton uniformly to the conveyor. The general appearance of this machine is shown in Figs. 1 and 2.

b The conveyor, either pneumatic or mechanical, or both, carrying the loosened cotton to the picker room. Fig. 2 shows the feeding-in end of a pneumatic conveyor, and Fig. 4 shows a mechanical conveyor.

c The pickers which have hoppers and feeding rolls to deliver the fiber to iron casings containing rapidly revolving metal beaters. The latter, with the assistance of air currents, separate the fiber from the dust. A line of these hoppers being fed by a mechanical conveyor, is shown in Fig. 4, and another line in Fig. 3, without any feeding mechanism.

As fires are almost sure to occur if heavy foreign material or matches enter the pickers or the fan of a pneumatic conveyor, it is important that all such material be removed at the bale breaker or before it is reached and that the various parts of the conveyor be properly arranged.

None of this foreign material is more difficult to remove than matches, as they weigh too little to separate readily from the cotton by ordinary means. In this matter more than in any other, preventing the matches from entering the stock is the only true solution of the problem. This has been actually accomplished in some mill properties by providing the help with safety matches to the exclusion of all other kinds.

PNEUMATIC CONVEYORS

The pneumatic cotton conveyor as it exists to-day is the outcome of attempts made in earlier days to save the labor of trucking baled cotton from the storehouse to the picker room. Mills having storehouses separate from their manufacturing rooms, and especially the larger mills, found this labor a considerable item.

At that time it had been common practice to convey damp cotton from dye house to drier by blowing it through a long sheet metal pipe attached to the discharge outlet of a pressure blower, the stock being fed in through the suction inlet of the blower (see *a*, Fig. 5). In applying this method to dry cotton fed by hand, however, fires in the blow pipe were common, and the air blast made them so intense that the arrangement in this crude form was considered far too risky for general use.

In many kinds of work the action of the air on the cotton in transit was found to be beneficial to subsequent working of the cotton; so much so, indeed, that manufacturers who had not at first thought it worth while, wished to use the blowing system.

The causes of these fires were found to be foreign substances in the stock, such as bits of iron, stones, or matches which had been carelessly dropped, or the wedging of the cotton in the fan casing due to the feeding in of masses which were too large to pass through. In some cases this fault was aggravated by the too small clearance in the fan between the blades and casing.

The number of fires with this arrangement was considerably reduced in some cases by using blowers

Presented at the Annual Meeting, New York, 1913, of The American Society of Mechanical Engineers.

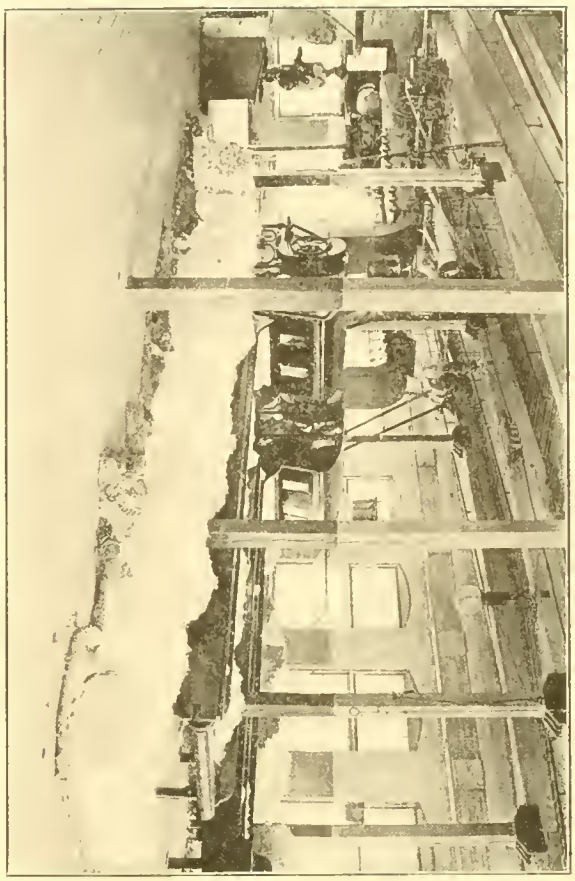


Fig. 1 Opening Room for Handling Large Quantities of Cotton Fed by Hand from the Bales to the Aprons

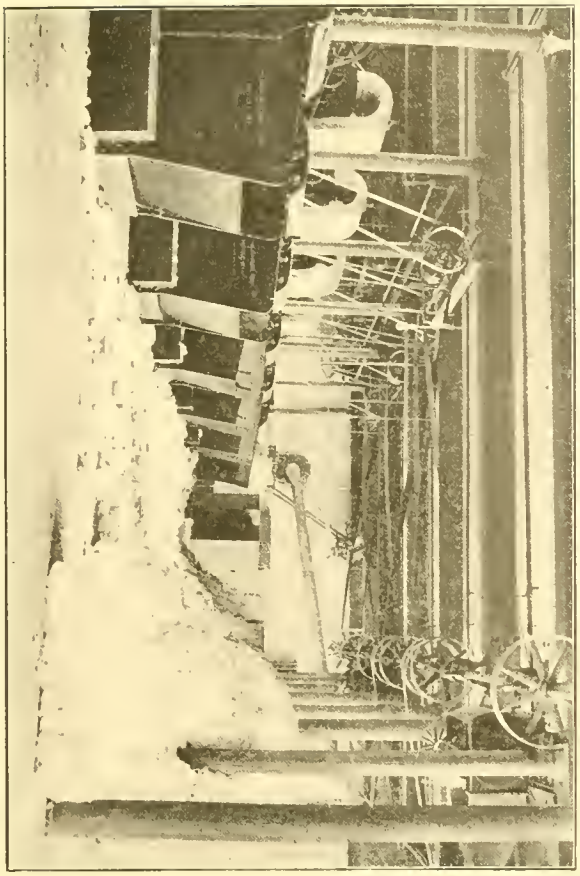


Fig. 3 Picker Room with Hoppers of Automatic Feeders Filled by Hand from Piles Fed from Condensers Above

Fig 2 Opening Room with Bale Breaker Delivering to a Conveyor Pipe under Suction, with Box to Catch Heavy Material

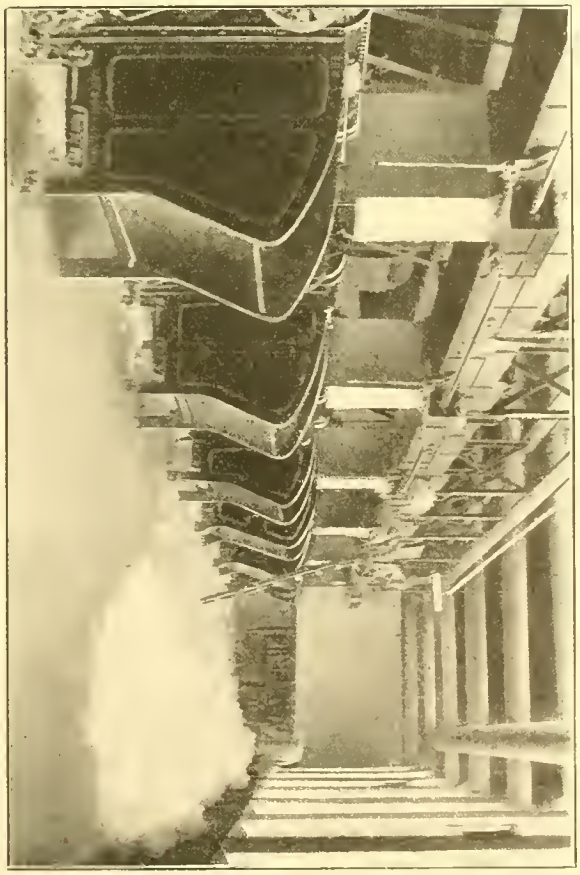


Fig. 4 Picker Room with Hoppers of Automatic Feeders Filled by Overhead Modern Mechanical Conveyor

having bronze blades. The introduction of the bale breaker or opening machine above mentioned in place of the irregular hand feed also contributed materially toward the elimination of fires from these causes (see *b*, Fig. 5.)

The general introduction of the cotton condenser in its improved form, however, furnished means for avoiding the objectionable blast of air and cotton in the bin or room, and of operating the entire

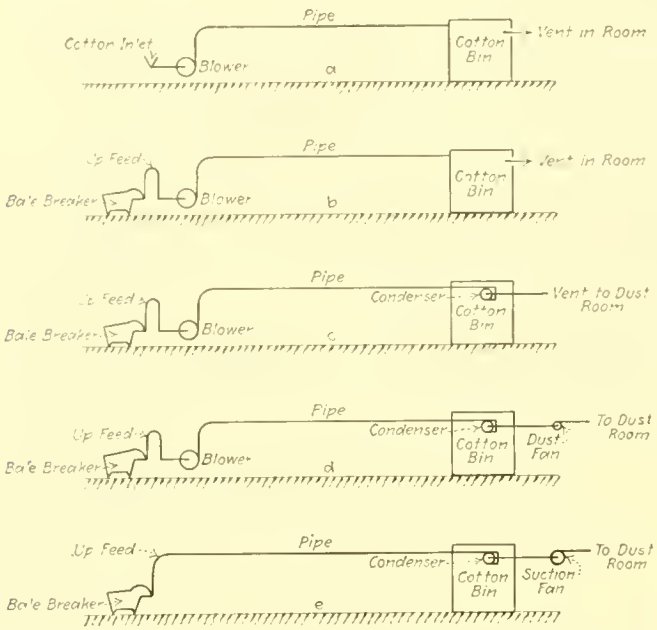


Fig. 5 Diagram showing Development of Suction System of Pneumatic Cotton Conveyor

system under suction instead of under pressure. This advantage of operating under suction entirely, however, was not at once recognized, and many systems were installed with the stock blowing through the fan discharging to the condenser (see *c*, Fig. 5), or with an auxiliary fan beyond the condenser smaller in size, and known as a dust fan (see *d*, Fig. 5).

The condenser consists of a slowly revolving cylindrical screen in a casing, with air pipe connections so arranged that the air current in passing through it, deposits cotton on the outer surface of the screen from which it is removed by a small roll, the cotton dropping lightly from this roll.

The final step to the present practice was to eliminate the blow fan, and to make the dust fan large enough to produce the necessary air current, thus making the cotton-carrying part of the system entirely under suction (see *e*, Fig. 5).

By placing the condenser and the cotton inlet both on the suction side of the fan, as in Fig. 5 *e*, or both on the discharge side of the fan, as in Fig. 10, no stock passes through the fan, and with systems so installed fires are a rare occurrence. For convenience in reference, the former is termed "Suction System" and the latter, "Pressure System."

SUCTION SYSTEMS

Under the most favorable conditions, pneumatic systems operated under suction have successfully handled through pipes up to 900 or 1,000 feet in length, quantities up to 4,000 lb. of cotton per hour. The limiting distances and weights of cotton are determined by local conditions such as size and tightness of pipes, number of bends, uniformity of feed, and adjustment of air passages through the condenser.

The sketch, Fig. 6, shows a modern safe cotton-conveying system taking cotton from an opening room through a suction pneumatic conveyor and delivering through a condenser upon a mechanical conveyor by which the cotton is carried to various points. This combination represents the best modern practice in the larger mills. In mills handling various staples, the discharge is often into bins instead of into machines.

In planning a new system for cotton conveying and distributing, or in remodelling an old system, the following conditions in the relative arrangement of parts should be approached as closely as possible in order to eliminate unnecessary fire hazards:

(*a*) *Removal of Foreign Substances.* Provision should be made for heavy substances to drop out of the stock before en-

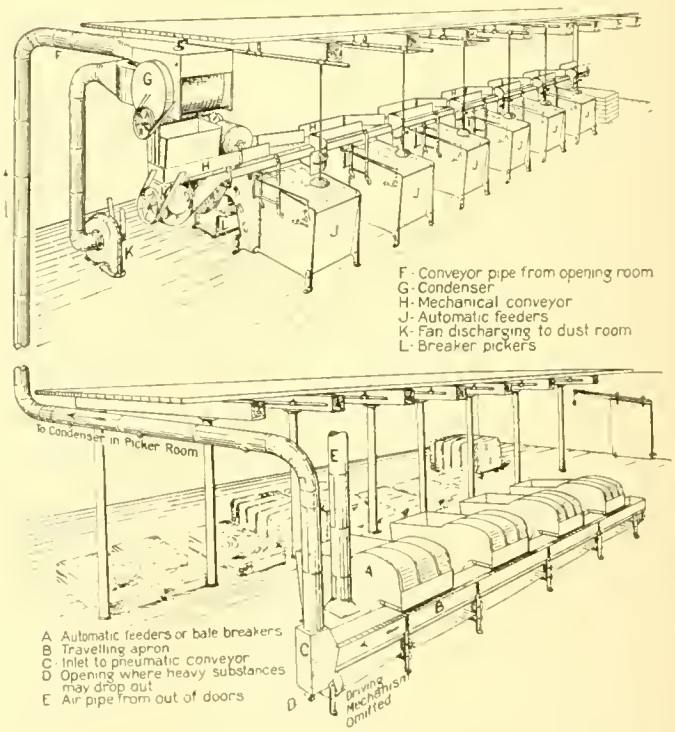


Fig. 6 Suction Pneumatic System Taking Cotton from an Opening Room and Delivering to a Mechanical Conveyor for Distribution

tering the conveyor pipe. This can be done by having the cotton pass vertically upward into the conveyor pipe, shaping the inlet like an inverted funnel or box

over the feed table or apron, and making the vertical part of the pipe about 12 ft. high (see Fig. 6). To obtain the desired vertical height it is sometimes necessary to use a long radius inverted U.

(*b*) *Location of Fan.* The fan should be so located that no cotton will pass through it. In cases of extreme length this condition can be met by installing two separate systems in series with a relay station at which the condenser of the first system discharges to the inlet of the second.

(*c*) *Disposal of Air Vents.* Air currents from the system should not discharge into the main rooms. This condition is usually met by discharging the air direct to the dust room.

(*d*) *Location of Pipes.* Long pipes should be generally located outside of main rooms and should not pass through important fire walls or floors. Trouble from condensation inside the conveyor pipe in cold weather, which sometimes arises, may be avoided by providing an auxiliary cold air inlet (see *E*, Fig. 6), and in difficult cases by covering the conveyor pipe, where out of doors, with non-conducting covering.

(*e*) *Pipes* should have joints riveted in addition to being soldered and have suitable handholes for cleaning. This is to guard

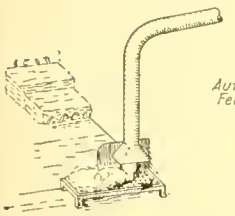


Fig. 7 Arrangement in Opening Room with Mechanical Conveyor Omitted

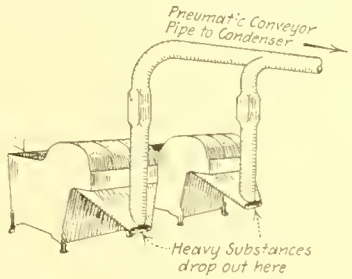


Fig. 8 Arrangement in Opening Room with Bale Breaker Omitted

against breakage of the pipe in case of fire from inside or outside the pipe.

VARIATIONS IN ARRANGEMENT

Variations from the arrangement shown in Fig. 6 are frequently necessary, depending on the number of varieties of stock, the quantity, quality, and distance to be carried, as follows:

(*a*) *Omission of Bale Breaker.* In the opening room of the smaller mills, the bale breaker or automatic feeder is often omitted and the cotton fed from a pile previously shaken out by hand from the bale. In this case the stock should be fed across a slatted movable table under the inverted cone of the inlet pipe (see Fig. 7). Uniform hand feed, however, is difficult and without the automatic feeder, frequent clogging of the condenser may result.

(*b*) *Omission of Mechanical Conveyor in Opening Room.* In some of the older systems or where more than one pneumatic conveyor is to be fed, the mechanical conveyor in the opening room is sometimes omitted by forming a pipe connection be-

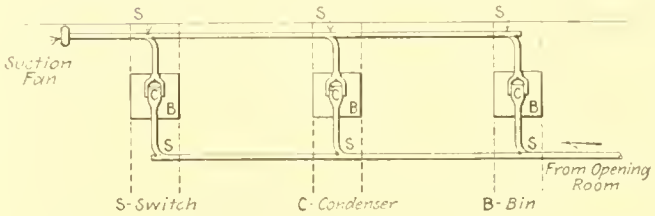


Fig. 9 Plan showing Arrangement in Picker Room with Mechanical Conveyor Omitted

tween the automatic feeders and the branches to the conveyor pipe. In such cases this connection may be in the form of a flattened conical pipe sloping downward and having an opening at the lowest point opposite the upward turn where heavy material may drop out (see Fig. 8).

(*c*) *Omission of Mechanical Conveyor in Picker Room.* At the picker room end, in case several staples are used, the mechanical conveyor is often omitted and the cotton delivered direct to bins through condensers. Under these conditions the condensers may be piped in parallel with proper switches and the same fan used for all (see Fig. 9).

PRESSURE SYSTEMS

In handling cotton mixed with some wool, as in knitting mills, felt mills, or colored cotton mills using a large variety of colored stock, pneumatic systems are usually operated under pressure instead of suction. The reasons for this are, that (*a*) stock containing above a small percentage of wool cannot be successfully handled with condensers, the greasy nature of the wool causing it to stick and clog the mechanism; and (*b*) in handling colored cotton the bins are often so small and numerous that the use of a condenser for each is impracticable. Mechanical conveyors are also objected to by manufacturers for handling colors on account of the liability that small tufts of stock caught in the mechanism will afterward find their way into lots of another color.

The pressure system improperly installed is dangerous to life and property, as the strong blast of air intensifies any fire in the pipe or near its outlet. The safest arrangement of such a system is obtained by observing the conditions already stated regarding

location and construction of pipes for suction systems, and also the following conditions:

(*a*) *Location of Fan.* With a pressure system, both the inlet and outlet for the stock should be placed on the discharge end of the fan. The stock may be introduced into the pipe by means of a hopper having at its bottom a vane or nozzle projecting into the conveyor pipe at such an angle as to cause an injector-like action at the point of

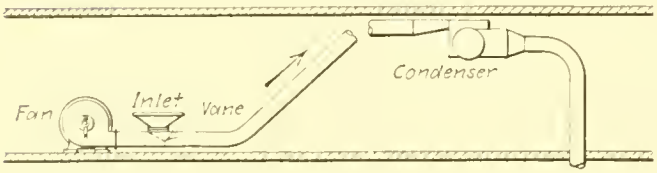


Fig. 10 Arrangement of Injector Inlet for Pressure System

inlet (see Fig. 10). This device is practicable, however, only for distances up to about 75 ft. Another method adapted for longer distances is to use a pair of flexible surfaced rolls forming the upper part of an air-tight feed box (see Fig. 11).

(*b*) *Vents.* At the delivery end, with either of the above arrangements, the pipe should terminate in a bin, with tight walls, with vent through a screen piped to such a point that no blast of free air can enter any important room.

MECHANICAL CONVEYORS

As with the best of machinery and with all the safeguards thus far described, all fires cannot be eliminated from the picker room, it is important that the extent of such fires as may still occur be made as small as possible. This is especially desirable in mills which

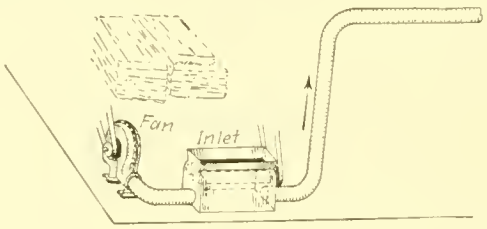


Fig. 11 Arrangement of Feed Box Inlet for Pressure System

store temporarily in bins in the room considerable quantities of opened cotton of various long staples.

Mechanical conveyors are often used between the opening room and picker room bins. In such cases these rooms are usually near each other. The older method of passing these conveyors through openings in partitions between adjoining bins has proved objectionable, as fire may enter several bins at the same time. To avoid this objection the conveyor can be placed over the tops of the bins, discharging through protected traps in the top. This arrangement requires considerable head room.

Another arrangement is to place the conveyor high up at the front or rear wall of the bin and discharge it through small protected openings in the wall. This can best be done where the bins are not deep from front to back, and where the conveyor has discharge from its side (see Fig. 12). In either case the openings for feeding bins from mechanical conveyors should be protected by tin covered shutters interlocking with the switch of the conveyor so each shutter will be open only when its bin is being filled.

SPRINKLERS

Having limited the number and extent of fires, the matter of controlling promptly those which do occur, should be cared for. In addition to the automatic sprinkler equipment always needed at the ceil-

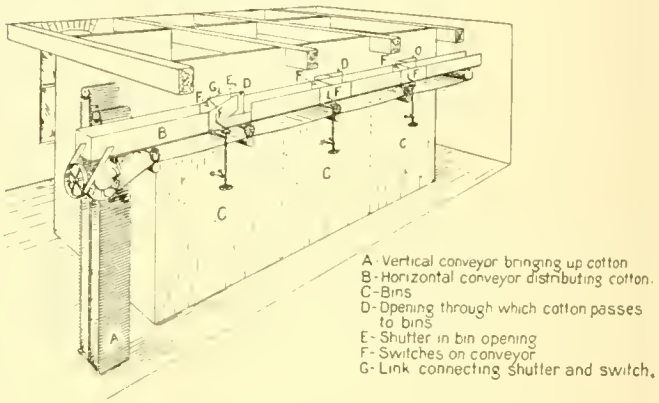


Fig. 12 Mechanical Conveyor so Located as to Discharge through Protected Openings near Top of Bins

ing of the cotton working rooms, sprinklers should be placed in the bins, in the condensers, under traveling aprons, inside and under picker trunks and close over the cotton in the hoppers of the automatic feeders.

DISCUSSION

Albert W. Thompson. Referring to the objection of Mr. Burnham to the using of relay fans, through which the cotton can pass directly, in cases of extreme length, in place of making substantially two systems, that the cotton in passing through the fan is likely to strike a fire due to the clogging, possibly from a poorly installed fan, from hot-bearings at the fan, or foreign substance passing through, if they get by the first point where they are supposed to drop out, do I understand this statement is based on actual experience? I have seen one or two systems of considerable length arranged in that way, and I do not recall now ever having seen a fire traceable directly to the fan. Most fires have originated in some other place, either in the opening room, where a device something like a picker is sometimes used for tearing bleached or dyed cotton, and where matches sometimes start fires; or at the finisher picker room at the other end of the system; but I do not

recall having seen a fire, directly traceable to the use of a relay fan.

C. J. H. Woodbury. I believe this paper is the first of its type which has been presented before any of the technical societies. That these occurrences in and of themselves are not preventable in any given instance appears to be conceded by Mr. Burnham, who correctly represents the practical experience in the matter. Many years ago, phosphor-bronze picker blades were introduced because they would not strike fire, or so it was stated; but whether that allegation was proved in practical experience beyond a diminution of such fires, is extremely doubtful. There is one class of distribution of such fires where it has been prevented, and that is the fires caused by striking in the picker and spreading down into the dust-room below, and then backing up through the dust flue into another picker which was not then in use. That has been prevented by unbalanced dampers at the end of the dust flues, so that when a picker was not in use, those dampers would naturally close and prevent that. I would like to ask the speaker if the principle of the automatic link, which has been applied so successfully to fire doors has not also been applied to dampers in these flues, so that whenever a fire occurs a flue would be closed at a very early stage in the story?

The illustrations represent the method of feeding the opener or bale breaker directly over open bales of cotton; whereas in many mills they put an ageing pile for the purpose of letting the cotton receive the air, and also get the effect of time in resuming its spirility, and its contact with other fibers, which it has lost by the compression it has undergone in the bale. There are various types of these ageing stacks in the English mills. They use them for the purpose of blending the various grades of cotton, or of mixing with the cotton the card waste, to the extent of making a new art almost in the blending of cotton for specific purposes, of which the American cotton manufacturers, I regret to say, know practically nothing. The cotton is put in strata in the pile from the various types of cotton, the Egyptian cotton, the American upland, and not forgetting as large a portion of card waste as the fabric will stand. Then they rake down the cotton along the end of the pile after it has remained there a week or so, with a large wooden garden rake, and a blending is effected in that manner. Another question is: Whether the exhaust blower is as efficient in moving cotton through rarefication of the air as a pressure blower would be?

John A. Stevens asked what data he has on fires caused by matches, referring to the paper in which he mentions fires started by matches; also where the large number of matches came from.

E. V. French. Mr. Woodbury has touched upon the matter of aging cotton. Where aging is done large mills may open 50 or 100 bales of cotton at a time. If a fire occurs under such conditions it is almost sure to run over the whole pile in spite of any extinguishing apparatus and cause a good deal of loss. Many mills on coarse work have found where the cotton is handled by blowing, that the passage through the pipes in loose form, and with an ample air supply, accomplishes about the same result as the ordinary aging. Only 10 or 12 bales therefore need be opened at once and the cotton from these is carried directly to the automatic feeder at the inlet of the blowing system. This gets rid of large amounts of loose open cotton, and makes a distinct gain in the reduction of the fire hazard. Picker rooms are causing a large number of our cotton mill losses and improvement at this point is the next thing to take up. If we can eliminate a good many of these fires the cotton mill will become about as safe as the average risk. In the question of matches which Mr. Stevens mentions, I remember one case where arrangements were made through a public officer to search the men in a cotton mill; the result was two handfuls of matches found in their pockets. As they work a match will now and then drop from their clothes to the floor, to be stepped upon or run over by a truck, and strike fire which will surely ignite anything combustible nearby. This is undoubtedly one of the most serious causes of fires in such mills today.

Charles H. Bigelow. In answer to Mr. Stevens, said that in the South he had seen the negro workmen handling matches and seen a number of fires caused by dropping the matches which were cracked by the trucks passing over them and set fire to the cotton, sometimes catching into the cotton on the truck.

The Author. In reply to the questions of Mr. Thompson, I know of one system where two fires occurred. It was a particularly long system, the fires blowing through the outlet side of the system, but no trace of fire had been found on the suction side of the fan.

Replying to Mr. Woodbury, in regard to stopping fires passing through the dust flues from the pickers by means of the fusible link, I do not think that method is extensively applied. I have heard of places where they tried to apply that method to cotton passing through pipes but I think the fire usually gets by the fusible link, as it takes a considerable length of time to melt the solder on the link. As to the unbalanced dampers, they are very efficient and I have no objection to urge against them. They are a great protection against fire backing up in the pipes.

The reference to the ageing qualities and the blower system, has suggested to my mind the fact that the quality of the cotton is improved by being blown through the pipes. I know of a number of cases where ageing bins have been put into mills for trial and then discarded as the passing of the cotton through the pipes was found to answer almost the same purpose. That may not be true of all cases, but it is in many. As regards the relative efficiencies of suction and blower fans, I have no data on that point; I think very few accurate measurements have been made to determine this.

Referring to the question of Mr. Stevens, the data are not exact, for as a rule in such cases the matches are destroyed. Some times we find the remains of the match, and often we find hard substances that have passed through. But many fires ascribed to matches are no doubt caused by matches, and we reach that conclusion from the fact that every other cause of fire we know anything of has been eliminated. That, perhaps, is not absolutely conclusive. The match fires, however, still remain the hardest ones to contend with or to trace to a cause.

In the South I think the laborers are largely responsible for many of the fires due to matches. The matches may be dropped by workmen around the gins, or even at earlier stages, before they get to the gins. It is a common practice among the negroes of the South to stick matches in buttonholes, in pockets, back of their ears, and in their hat-bands.

TEXTILE COST ACCOUNTING: ITS PURPOSE AND APPLICATION

By C. B. Annett,[1] New York

and

C. F. Cunningham,[1] New York

Non-Members

Cost accounting, as the name implies, is the application of the science of accounting to the determination of costs. Its fundamental principles are applicable to all lines of industry. It is really only a detail of the large question of organization, and it is therefore evident that this detail cannot be solved independently. There must be:

a "A clear definition of the departments of the business so that similar work and similar functions shall be grouped in one department.

b "A positive definition of duties of each department and its relation to the general business.

c "A clear fixing of the responsibility and a willingness to have responsibility rest with the heads of the various departments.

d "Scrupulous care to communicate the various wishes of the Chief Executive through the proper channels, that the responsibilities fixed may be preserved and each department limited to its particular functions.

e "The harmonizing of the commercial accounts, that is, the representative accounts of the business with the general scheme which is to be followed in the factory accounting or cost-keeping department. . . .

f "A proper head to the department of cost-keeping who must be as much an engineer as an accountant, and capable not merely of compiling figures, but of using the information when the facts are compiled; for the end of cost-keeping is cost reduction. This man must be so efficient that he may be depended upon by the highest official of the company and he will naturally be high in the counsels of the latter. . . . A man who fills such a position will have no sinecure."[2]

It is perfectly obvious that costs which are inaccurate, are not worthy of consideration and in fact are worse than none at all, as they are often entirely misleading. It therefore seems desirable before entering upon a discussion of specific methods of obtaining costs, to discuss briefly the fundamentals essential to all cost accounting.

The first essential is that cost should be a statement of fact, all assumptions, in so far as possible, being eliminated. In contradistinction, an estimate, or estimated cost, may not agree with the real cost because of the very fact that it takes into consideration probable changes of conditions.

The lack of a clear understanding of the difference between a cost and an estimate, has frequently led to much confusion and the distinction between the two cannot be too clearly defined. Many manufacturers seem to fall into the habit of allowing themselves to believe that cost is what they wish it to be, rather than a statement of the real facts, and this almost invariably leads to disaster.

To make this important point clearer, consider that an order for a fabric has been received, conditioned on a certain price. The records show that this fabric was previously made at a certain cost. It obviously would not do to accept the order without taking into consideration all changes in conditions that have taken place since the former production. Wages may have increased, automatic looms may have replaced plain looms, the price of raw material may have advanced, and a number of the elements of cost may have changed, which would alter the previous cost. Consequently an estimate is made, based on the known facts taking these changes into consideration as accurately as possible. The order is accepted because the estimate indicates that, provided the conditions considered therein hold true, a profit should result from the sale. During the actual manufacture of the order, however, alterations of conditions occur which were not anticipated in the estimate. The production decreased, the shrinkage increased, the percentage of second quality good increased; perhaps a number of such cost factors varied. In consequence the anticipated profit becomes doubtful and it is, therefore, evident that the estimate cannot be used as a guarantee of profit. After the fabric is completed, the cost is carefully compiled and the true cost, regardless of the existing conditions, determined. This affords a proof of the accuracy or inaccuracy of the preliminary estimate, determines whether or not the order has been profitable and becomes a basis for estimating more accurately on future orders.

The second essential is predicated upon the first, that if cost is to be a statement of fact, it must be subject to proof. In order to insure this, it is essential that the person responsible for its compilation have full access to the most private information of the company's affairs and the unqualified confidence of its officers in order that every item of expense be included. Further, the accounting methods should be so arranged that the results obtained are carried to, and incorporated in, the commercial (private) books of the company.

[1] Gunn, Richards & Co.

[2] James Newton Gunn, "Engineering Magazine," January 1901

Presented at the Annual Meeting, New York, 1913, of The American Society of Mechanical Engineers

The third essential is that the several departments involved work in complete harmony. All persons having to do with the recording and tabulating of statistics must work together for the single purpose of reporting information not alone accurately, but also promptly, in order that the data so recorded may be available before they become history. The sources of much of the information essential to cost must, of necessity, be from persons in the mill who are of a grade of labor lower than that responsible for the compilation of the costs, and, it is especially necessary, therefore, that they be impressed with the importance of the information they are recording.

The control of all materials not in process should be under the direction of a general storekeeper, and the control of production under a production manager.

It should be the function of the production manager to control production from the raw material to the finished product. Changes in production methods should be made only through the production manager and it should be his duty to at all times keep the cost department fully informed as to the methods in force and the quantities produced.

The general storekeeper should have charge of and be responsible for all raw material, semi-finished and finished stock wherever located. This does not necessarily imply that all stores should be centralized in one place, but it does imply that one person should be held responsible for their proper care and for correct reporting of the receipts and disbursements of all materials.

Manufacturers sometimes argue that because their material is not liable to depletion by theft, from the lack of its value to an individual, they may safely figure their costs on the basis of a theoretical schedule of the material that should enter into any given unit of their product. Similarly, all indirect materials purchased are sometimes charged directly to expense and all direct materials to product, but this procedure is apt to prove embarrassing at times, as there will be an inventory of material on hand which theoretically has no value because it has already been charged to product. Moreover, this practice is not conducive to accuracy as purchases of material are not necessarily made according to the manufacturing need for this material. It is usually found that savings may be made by buying in quantities sufficient for several months' normal operation of the mill.

Total cost may be divided into three main parts or divisions: (*a*) manufacturing or mill cost; (*b*) selling cost; (*c*) administrative cost. The latter two are generally known as commercial expense and are distinct from manufacturing or mill cost. They are usually combined and added to the manufacturing cost on a single percentage basis. While this is reasonably correct in a great many cases, it should be avoided wherever it is possible to obtain a more equitable basis. Many manufacturers dispose of their product through a selling agency or commission house, and therefore know exactly the selling expense chargeable to each fabric and should accordingly, apply this selling expense directly to the product.

Manufacturing cost is the sum of the following: (*a*) direct material cost; (*b*) direct labor cost; (*c*) indirect cost or burden.

Direct material cost includes the cost of all material entering into the product and directly assignable to it, and direct labor cost the wages paid which are directly chargeable to the product.

Indirect cost or burden includes the cost of labor and material and miscellaneous expenses not directly chargeable to the product, such as superintendence, power, heat, light, depreciation, etc. Speaking generally it includes all items not included in direct labor or materials.

Each of the above may be subdivided, if desired. The indirect cost, particularly, is a complex item and can be treated more readily if segregated, for instance, into (1) power, heat and light; (2) departmental expenses; (3) general expense.

The cost of power, heat and light includes all expenditures incident to the production and distribution of power, heat or light. It is desirable to distribute the cost of power, heat and light by actual consumption. Obviously more power is required to operate a heavy 72-in. loom than a light 28-in. one. A department using steam for manufacturing and heating should be charged proportionately more for steam than a department using it only for heating. The proper percentage may be obtained by actual measurement or it may be approximated from tests. While the former method is preferable, the latter is sufficiently exact if proper facilities are had for making accurate tests.

Departmental expense includes all items of expense which can be charged directly to a department, for instance, departmental supplies, foreman's wages, fixers' wages, etc. It can be apportioned to the product by one of a number of methods.

General expense includes all items of expense which are not directly chargeable to a department, and which therefore must be apportioned to the departments on a more or less arbitrary basis.

There are two general methods of collecting cost data: (*a*) by definite lots or orders; and (*b*) by operations. As the name implies, the first method provides for the determination of the cost of definite quantities of product and is applicable only to cases where the material can be processed in definite lots and kept intact through the several operations. These requirements render this method impracticable in such textile mills as largely manufacture what are known as staple products. The production in such cases is so continuous that it cannot be readily segregated into lots or batches. The plan is therefore applicable only to what are known as specialty or fancy mills in which

it is the general practice to process the material in lots of comparatively limited quantities.

In order to insure that all expenditures incurred are included in the cost, it is necessary that all labor performed and material consumed should be charged to some form of order: Production orders for all labor and material expended on product intended for sale, plant orders for all expenditures for plant improvement and extension, and standing orders for all expenditures that cannot be charged directly to either production or plant orders.

Production orders should be issued as the authority for processing all materials entering directly into the product. They should be numbered serially and all expenditures of labor and material on account of same should be charged to these numbers. It should be noted that it is not essential that an order should cover the complete process from raw material to finished product, but it is necessary that it should cover a complete stage of production.

Plant orders, like production orders, should be numbered serially and should serve the purpose of collecting the various items of labor and material expended on plant improvements and extensions.

Standing orders should be issued for collecting all expenditures of labor and material necessary for the efficient operation of the mill except those chargeable to production and plant orders and they will, therefore, embrace all indirect cost items. By means of standing orders, a minute and careful periodical comparison may be had of all manufacturing, administrative and selling expenses.

All disbursements of materials from stores should be priced at cost and charged to the proper order number. This will not only insure that all expenditures of material are accounted for, but it will also provide a means of collecting individually the material cost of the several orders.

There are several methods in use for collecting labor cost data. It has been in the past quite generally the practice to allow the workman to make his own record, or have his foreman or overseer do it for him. A better plan is to place the responsibility upon timekeepers, whose sole duty it is to collect labor information. Timekeepers should be supplemented, so far as possible, with mechanical recorders which can neither err nor misrepresent.

After obtaining the direct material and labor cost, the next step in the tabulation cost is to apply the indirect cost or burden. We shall not attempt to discuss at length the various methods of distributing indirect cost. The problem is much simplified if the departments are so defined that only similar operations and processes are contained within a single department. Distribution of expenses may be divided into two parts: first the distribution of the general expense of the mill as referred to above, together with power, heat and light to the producing departments; and second, the apportionment of the total departmental expense thus obtained over the product passing through the departments.

The first is not, in reality, extremely difficult, but it does require a certain amount of patience and study to determine the most equitable method of distributing the several items making up this general expense. Power, for example, as mentioned previously, should be distributed on the basis of power consumed, depreciation on the basis of the value of the plant and equipment used by the department. In a similar manner each item of general expense should be taken up, and the most equitable method of distribution determined.

The total departmental indirect cost thus obtained may be apportioned over the product by any one of several methods. It is quite generally desirable in textile mills, however, to use the machine hour basis or its equivalent, as the machine is largely the unit of production.

It will be readily seen that the cost of direct material and direct labor can be determined as soon as the order is completed, but that the exact amount to be added for indirect expense cannot be ascertained until after the close of the period.

It is, therefore, common practice in figuring current costs, to use the rates based on the results of previous periods. While this is the only practicable method to pursue when immediate cost figures are required, it nevertheless, is liable to error and should only be used when it is not practicable to wait until the close of the period.

The second method, that of operation costs, as the name implies, provides for the determination of the cost of individual operations. It is self-evident that, given the total cost of each operation and the loss by shrinkage of material from operation to operation, the total cost of any product, or the cost at any desired stage of completion may be found by combining these costs in the proper manner. They must, however, be combined only with a full knowledge of the shrinkage and the exact order in which the several operations were performed. This method is applicable to mills in which production is continuous, and, therefore, is adapted to a large class of textile mills, especially those manufacturing staple cotton goods.

The foundation of operation costs rests upon an accurate knowledge of the production of each operation, or, stated another way, of the shrinkage from operation to operation. There are in use several methods of measuring production, but none of them are entirely satisfactory.

Because of the well-known fact that the majority of the fibres used in the manufacture of textiles are subject to a considerable variation in weight, due to the rapidity with which they absorb and discharge moisture, if weight is used as the unit of measure it is subject to a corresponding variation. While lineal measure would solve this difficulty it would so com-

plicate the recording of the quantities of stock in process as to make the plan impracticable. Everything considered, the most practicable unit of measure for yarn, both finished and semi-finished, seems to be the pound. Cloth may be measured either by the pound or the yard, whichever is the more convenient.

As it is impracticable to actually weigh the product after each operation it is necessary to resort to some mechanical method of measurement. The most common method is the use of measuring clocks. Clocks are subject to possible error in that they measure the production based upon a fixed standard of efficiency, while it is, of course, self-evident that any individual machine will fluctuate in its efficiency due to a number of causes.

The collection of the cost data under this plan differs from that used in the first plan, in that there is no special production order number against which the various expenditures of labor and material can be charged and it is, therefore, necessary to use the operation as the unit of cost. It is essential to this scheme that the various operations be definitely determined and designated by a number. The several different kinds of product should also be numbered. A special ledger for collecting the cost data should be furnished in which provision should be made for collecting the direct material costs separately from the direct labor and the indirect cost.

All disbursements of direct material from stores should be priced at cost and charged in the mill ledger to the first operation through which the material passes, classified to kind of raw material. Provision should be made for crediting the several raw material accounts with the value of the waste made in each operation. The direct material accounts should be subdivided as to kind of raw material, rather than kind of product, as it is usually impracticable to obtain a report of waste classified as to kind of product. At best, the obtaining of accurate reports of waste made is a difficult proposition, especially in a mill where several kinds or grades of raw material are being processed along the same general lines, and quite possibly in the same rooms. It is important that this information be obtained as accurately as possible, in order that each operation and each kind of material may be credited with the proper amount for waste. The customary practice has been to consider that the shrinkage is the same for all kinds and grades of raw material and product. Shrinkages, on the contrary, are constant only in so far as the cause is either natural or due to mechanical appliances, and shrinkages due to "human elements" are subject to wide variation. Considering that the waste in woolen mills is over 50 per cent of the raw material and in cotton mills over 15 per cent, it seems well worth while to give this problem serious consideration. A mill agent once pointed to his waste wagon and aptly remarked, "there go our dividends." Apparently in many cases dividends might be increased if more attention were given to the reduction and utilization of waste.

All direct labor should be analyzed as to operation and kind of product and charged in the mill ledger to the proper account. The total indirect cost for each operation should be determined in much the same manner as explained under lot costs. It should then be apportioned to the several kinds of product and charged to the proper accounts in the mill ledger. At the close of any period, the unit cost of any operation may be determined by dividing the total expenditure on the operation for the period, as shown by the mill ledger, by the total amount of product which has passed through the operation during the same period.

The total cost of any given product cannot be determined simply by adding together the several operation costs, considering the shrinkage from operation to operation. To obtain the cost of any operation in the completed product, it is necessary to increase the operation cost, in reciprocal proportion to the shrinkage from the end of that operation to the finished product. For example, if the cost of an operation is \$0.015 and the shrinkage of product is 25 per cent, the operation cost in completed product would be $\frac{\$0.015}{100\% - 25\%} =$ \$0.02. It would be possible to determine the total cost of product by this method, except for the fact that the exact sequence of operations is not readily ascertainable, making it impossible to determine accurately the amount of shrinkage, especially in a mill making a variety of products.

A more satisfactory method is to build up the total cost, operation by operation, beginning with the first operation and charging forward to each succeeding operation the cumulative cost of all preceding operations, inventories of course considered. This plan has the advantage, in that it follows the product from operation to operation, according to the manufacturing layout and schedule.

It is obvious that the output of an operation plus the waste made is equal to its input. Providing no inventory exists between this and the succeeding operation, the good output of the first operation is equal to the output of the second, including the waste made. Ordinarily, however, inventories do exist and must, therefore, be taken into consideration. An equation taking inventory into consideration may be made up as follows: The good output of the first operation, plus the inventory of the product of that operation at the beginning of the period, less the inventory of that operation at the end of the period, is equal to the input of the succeeding operation. If it were practicable to determine the input of each operation, it would be possible by means of this formula to determine the inventory on hand between operations, at the end of any period; but in most instances there seems to be no practical method of obtaining the input of each operation. Consequently, a physical inventory

of the product in process must be taken whenever the inventory is desired. With the inventory a known factor, by means of the above equation the quantity and value of the product to be charged forward from operation to operation can be easily determined. Each successive operation should be charged with the total cost of all preceding operations, inventories considered, and by this means it thus becomes possible to determine the accumulated cost of any product at any stage of completion.

The accumulated unit cost may be obtained by dividing the accumulated cost at that stage of production by the output of the operation. This unit cost should be used in pricing the physical inventory of the product from that operation.

In many cases, the product of one operation is made into a number of different kinds of product in a succeeding operation. For example, one size of roving may be spun into several sizes of yarn and it is necessary in such cases to apportion the amount charged forward from the previous operation to the succeeding operation, based on the total production of each kind of product in the succeeding operation. It will be evident that by this method of cost finding, the inventory of product in process is automatically priced and, further, that it is possible to determine the cost of the product shipped during the period. The operation cost method not only provides for obtaining the detail costs by operations, but also the total cost of each kind of product.

Cost accounting is most valuable from the standpoint of the manufacturer, in that it shows numerous ways for reducing operating costs. It is self-evident that accurate costs are of fundamental importance as a guide in determining whether to meet or withdraw from unintelligent competition. They are also essential in the preparation of financial statements, as a knowledge of costs is absolutely necessary to the proper valuation of assets, and for the making up of a profit and loss account.

As heretofore mentioned, a mill or inventory ledger should be opened, designed to collect and control the various facts regarding the manufacturing costs and inventory records. This should be done regardless of whether costs are determined by means of the definite lot or operation plan. The mill ledger should be controlled by the private ledger and at the close of each period should be in balance with the controlling account in the private ledger.

The various items of expense not distributed or applying to product in process, should be so segregated that they can be easily checked against uncompleted costs and the uncompleted costs in turn checked against the product in process account. By this means at the close of each period, be it one or four weeks, or one of the calendar months or several months, the accuracy of the costs compiled during the period is demonstrated.

SPECIFICATIONS FOR FACTORY TIMBERS

By F. J. Hoxie, Phenix, R. I.

Member of the Society

This paper is given in the hope that a discussion may be opened which will bring together scattered experiences relative to the properties underlying the qualities required in mill timber. Within three years more than $100,000 has been required to repair damage due to dry rot in mills insured by the Associated Factory Mutual Fire Insurance Companies, and nearly all of the lumber affected was hard pine in comparatively new buildings. This rapidly increasing destruction of lumber is unquestionably due to the use of poorer material than was employed in former years. In a lot of large timber for the frame of a new mill will be found nowadays scarcely anything but North Carolina, Cuban, or Shortleaf pine. The best qualities of these varieties are probably as resistant to decay as is the Longleaf pine, but they are less uniform; the poor qualities are much more difficult to detect because of the necessarily superficial acceptance inspection of the purchaser or his representative.

In textile mills the high artificial atmospheric humidity undoubtedly increases the tendency to rot in pine of low natural resistance to fungus. The weaving rooms of cotton mills are frequently maintained at a saturation of moisture of 70 to 80 per cent. With 70 per cent saturation and a temperature of 80 deg. fahr. a decrease in temperature of 12 deg. or more would cause precipitation. This condition can be found in winter on the under side of roofs or at beam wall bearings or windows if the heat insulation is not very complete.

Dry rot fungus will grow on the surface of wood at atmospheric saturation from 96 to 100 per cent[1]; it will grow inside of large beams of susceptible material at a much lower atmospheric saturation. In one case investigated, the room was maintained at 60 per cent and the beams of the second floor which were not exposed to outside temperatures were attacked. Experiments tending to show that the dry rot fungus is able to form sufficient water for its requirements in beams of large size by decomposition of the wood are given by Mez[2]. Wet spots frequently remain several days on the freshly sawed surfaces of beam sections containing living fungus (see Fig. 3). There is no question whatever about its growing inside of factory beams of non-resistant material for two or three years at least after the factory is built, with less than 70 per cent of atmospheric moisture and in rooms where water

[1] Hausschwammforschungen, vol. 6, p. 308; Moeller, Jena, 1912.

[2] Der Hausschwamm, Carl Mez; Dresden, 1908, p. 192.

Presented at the Annual Meeting, New York, 1913, of The American Society of Mechanical Engineers.

is not used in manufacturing processes. This condition has been found in several of the worst cases investigated.

Only hard pine timber will be considered here as this is the most generally used material for heavy mill frames. Spruce is sometimes used for floor plank, but this is probably more susceptible to rot than the better qualities of hard pine. In the only case investigated where spruce was concerned the disease evidently spread from pine beams to the spruce floor planking.

Fig. 1 Longleaf Pine, 8 in. by 18 in. Distribution of Resin: *A* 25 Per Cent, *B* 14 Per Cent, *C* 17 Per Cent, *D* (Sapwood) 3 Per Cent

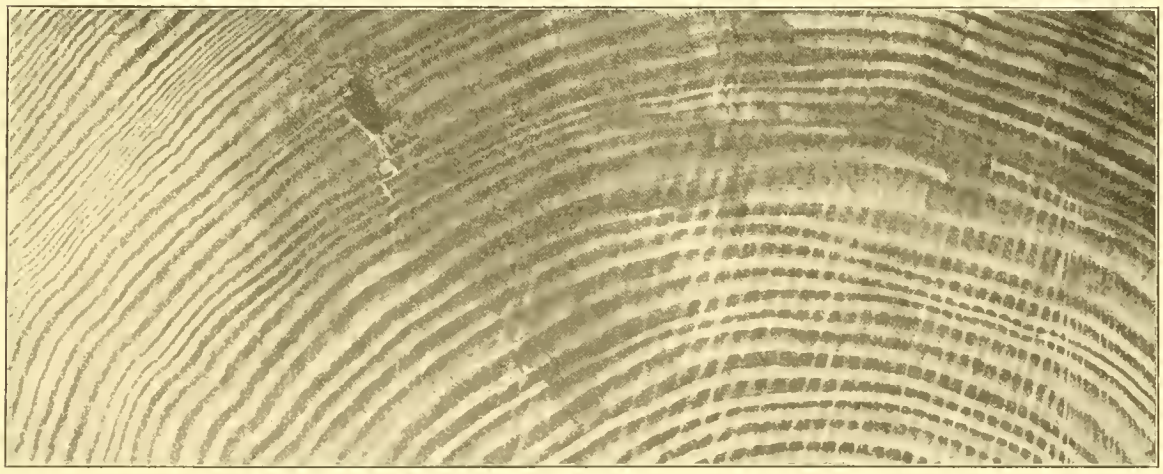


Fig. 2 Cuban Pine, 8 in. by 18 in. with Rot in Sapwood

In a few cases hemlock without antiseptic treatment used under floors in basements has failed in a few years. Hemlock, oak and white pine have failed after longer or shorter service, but the use of these materials for mill construction is not sufficiently frequent to require more than passing mention.

Twenty-six varieties of hard pine, growing in North America, are described by Penhallow:[1] of these only four are much used for timber in the eastern states, the Longleaf (*Pinus Palustris*), Shortleaf (*Pinus Echinata*), Cuban (*Pinus Heterophyila*), and North Carolina (*Pinus Tæda*). They are very fully described in Timber Pines of the Southern States, by Charles Mohr.[2] The Longleaf pine is the most valuable for lumber from its greater strength and durability. The latter quality is probably due chiefly to the high percentage and uniform distribution of the resin and to the small percentage of sap wood, which averages not over 2 in. in radius of mature trees, while that of the other three varieties varies from 4 in. to 6 in. of the radius.

Many of the specifications for hard pine are vague or meaningless owing to the fact that the terms used are not clearly defined or are not determinable. For example "best quality" could honestly be taken to mean either the best in the local market or the best in the world. "Longleaf pine" is practically impossible to identify beyond a doubt in the form of lumber, and in fact it is now rather the exception than the rule to find this variety of pine in the large sizes required for mill beams. Other varieties are regularly accepted

[1] A Manual of the North American Gymnosperms, D. P. Penhallow, 1907.

[2] Bulletin No. 13, U. S. Department of Agriculture, Division of Forestry, 1897.

as Longleaf. "Georgia" is sometimes added to a specification but lumber grown in that state is seldom insisted upon, nor is its place of growth important.

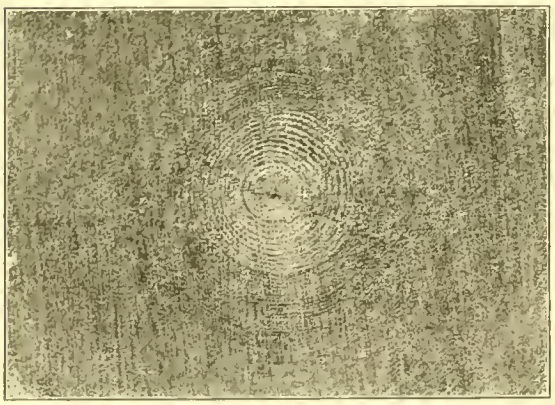
The interstate rules for Yellow pine lumber for 1905 define prime quality, dimension sizes, as follows:

All square lumber shall show two-thirds heart on two sides, and not less than one-half heart on two other sides. Other sizes shall show two-thirds heart on face and show heart two-thirds of length on edges, excepting when the width exceeds the thickness by 3 in. or over, then it shall show heart on the edge for one-half the length.

the deep, narrow sections frequently used for double beams.

The average number of annual growth rings per inch has been suggested as a criterion for selecting good hard pine lumber, as follows:[1] first quality should have 15 or more rings per inch, as an average of 5 in. across the grain; second quality should have an average of from 8 to 15 growth rings, and material having less than 8 should be considered unfit for structural use. This would admit such material as that shown in Fig. 4 and exclude such as that shown in Fig.

Fig. 3 North Carolina, or Loblolly, Pine, 8 in. by 18 in. with Rot in Nonresinous Wood



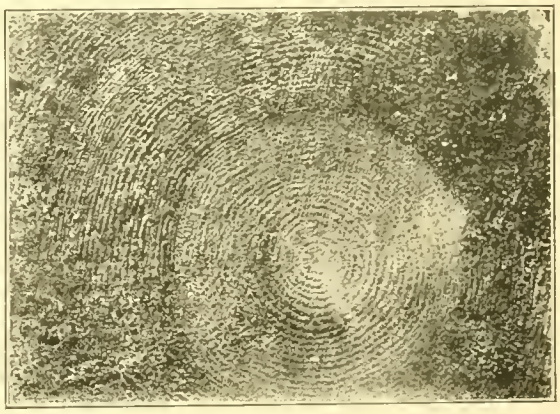


Fig. 4 Sound and Rotted Sections of 12 in. by 14 in. Beams; Probably Shortleaf Pine

The rules define merchantable inspection as follows:

All sizes under 9 in. shall show some heart the entire length on one side. Sizes 9 in. and over shall show some heart the entire length on two opposite sides, etc.

This specification for prime quality loses most of its force when applied to pine of the type shown in Fig. 4. The young heart wood has rotted nearly, or quite as rapidly, as the sapwood. Most of the beams shown in Fig. 6 are of this variety. Timber of merchantable inspection, in addition to the uncertainty of the heart wood mentioned above, has the practical certainty of rot in the sapwood if conditions are not most favorable. This grading is particularly treacherous with

5. The dense coarse grained resinous Cuban heart wood is as strong and durable as the Longleaf pine, its bad quality being that it has a large percentage of not very clearly marked sapwood which is rapidly destroyed by fungus (see Fig. 2).

A later suggestion which has been adopted by the American Society for Testing Materials[2] calls all good material Longleaf pine and poor material Shortleaf pine. This is unfortunate in that an arbitrary mean-

[1] American Society for Testing Materials, Proceedings 1909, p. 291.

[2] American Society for Testing Materials, Proceedings 1912, p. 345.

Fig. 5 Beam 8 in. by 12 in., Weighing 72 lb. per Cu. Ft.

ing is given to the names Longleaf and Shortleaf, which already have a generally accepted botanical meaning; such a discrimination is also incomplete in not defining the qualities of the two classes.

The positive identification of Longleaf pine lumber is difficult or impossible. There are slight microscopic differences in the form of the medullary rays of the North Carolina pine, as given by Penhallow[1] and Roth,[2] but to use them for identification would require considerable experience in the microscopic study of the pines. The macroscopic differences are more striking with characteristic specimens. The Longleaf pine is heavy, resinous and fine grained, averaging for the dry heart wood from the butt of the tree, according to Sargent[3] 43.7 lb. per cu. ft. (see Fig. 1). The Cuban pine is slightly heavier, averaging 47 lb. per cu. ft., resinous and coarse grained with a large proportion of dense summer wood and a much larger proportion of sapwood (see Figs. 2 and 5). The North Carolina pine is lighter, averaging 34 lb. per cu. ft., somewhat less resinous, coarse grained with a small percentage of summer wood (see Fig. 3). The Shortleaf pine is moderately light, averaging 38 lb. per cu. ft., the least resinous of the four and of medium coarse grain. The following are the weights per cubic foot given by Mohr for kiln dried material; Longleaf 36 lb., Cuban 37 lb., Shortleaf 30 lb., and North Carolina 31 lb. The reason for Mohr's weights being less than those of Sargent is that he takes the average of the tree, the top of which is much lighter, while Sargent considers only the denser heart wood at the butt. There is consider-

[1] North American Gymnosperms, D. P. Penhallow, 1907.

[2] Bulletin No. 13, U. S. Division of Forestry, 1897, p. 143.

[3] Silva of North America, C. S. Sargent, 1897.

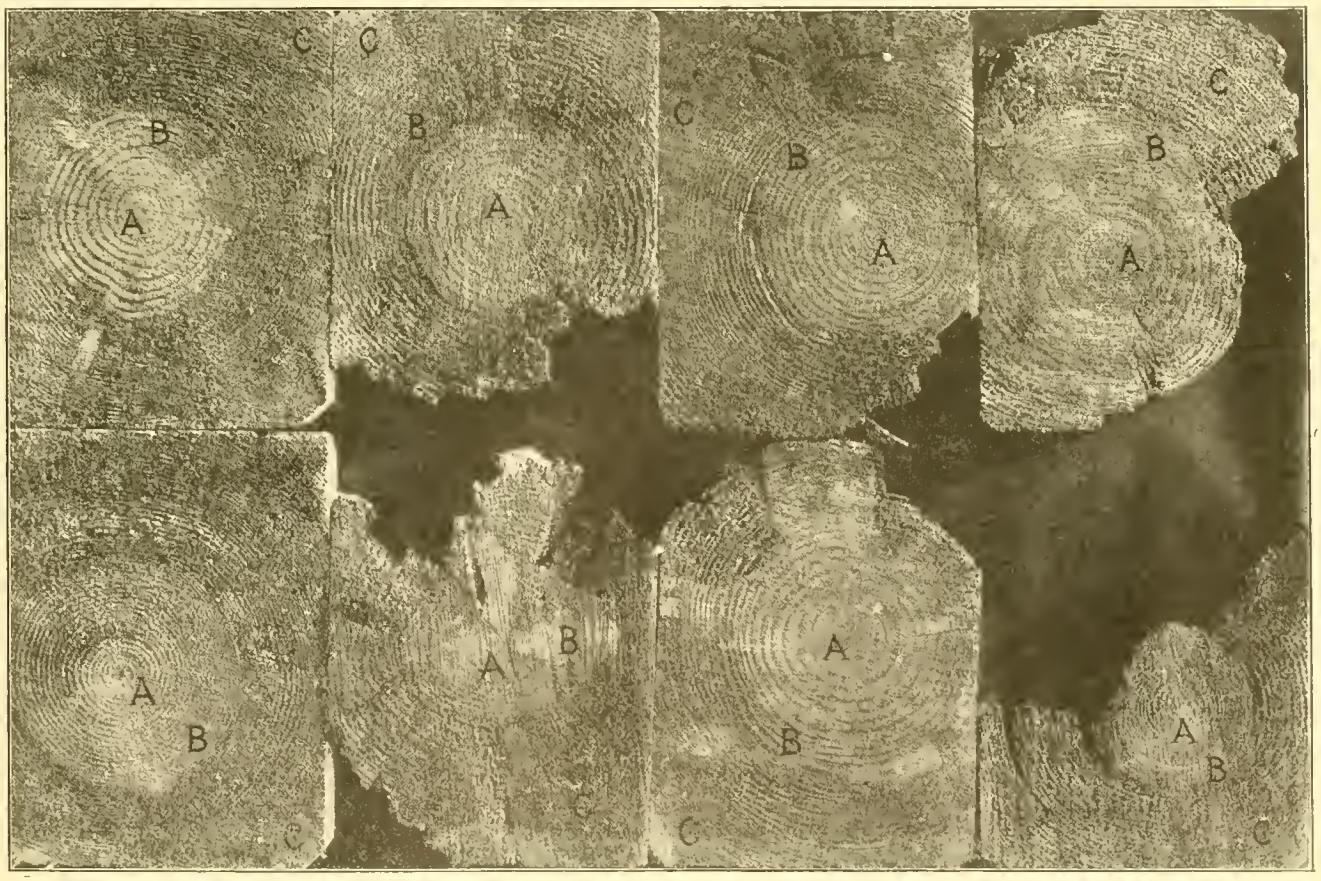


Fig. 6 Rotted 12 in. by 16 in. Pine Beams Removed after Two Years' Service

Resin, Per Cent

A	B	C	A	B	C	A	B	C	A	B	C
7 72	5 12	0 83	8 36	4 89	1.17	4 46	1.99	0.76	5 36	7 04	0 68
9 45	2 31	0 82	3 45	18 81	0 99	6 26	6.56	0.58	29 21	12.17	0 88

able confusion in local names: Mohr gives six Latin and 29 common names as having been used at different times or different places for the Longleaf pine; the other varieties have nearly as many. The Cuban and Longleaf pines are sometimes confused since both have long leaves, while the Shortleaf and the North Carolina have short leaves.

A treacherous type of hard pine is shown in Fig. 4, which is probably Shortleaf pine, although it may be Longleaf grown under unfavorable conditions. The percentage of resin and the gravity is somewhat higher than that given by Mohr[1] for Shortleaf, but the arrangement of growth rings corresponds with his description. Hardly a lot of lumber is to be found of which this does not form a considerable proportion. Most of the rotted beams shown in Fig. 7 are of this type. It is characterized by a coarse grain at the center, generally consisting of four to six growth rings per inch, becoming regularly finer with increased diameter until at 6 in. or 8 in. from the center there are 20 to 30 growth rings per inch. The resin and resistance to rot decrease with the rings. At the center there is generally in the neighborhood of 10 per cent of resin; at 4 or 5 in. from the center there is frequently less than 3 per cent. The line between the heart and sapwood is well marked, the heart being much darker than the sap, as with the Longleaf. This material is regularly sold as Longleaf.

Tannin in the lignified heart wood is said to retard fungus growths in oak,[2] but resin is the important factor in the hard pines. The following experiment was made to show the effect of resin: A block of Longleaf pine 2 in. on a side, containing 18 per cent of resin was sawed in two across the grain. Half of it was boiled in benzole and after the removal of the resin the benzole was driven off. Both pieces were cultivated in contact with wood containing living dry rot fungus. At the end of a year the specimens were dried and weighed. That from which the resin had been removed had lost 8 per cent in weight, the other only 2 per cent.

Cuban pine is the heaviest and frequently the most resinous of the timber varieties. Fig. 5 shows a section of a beam weighing 72 lb. per cu. ft. It can be seen

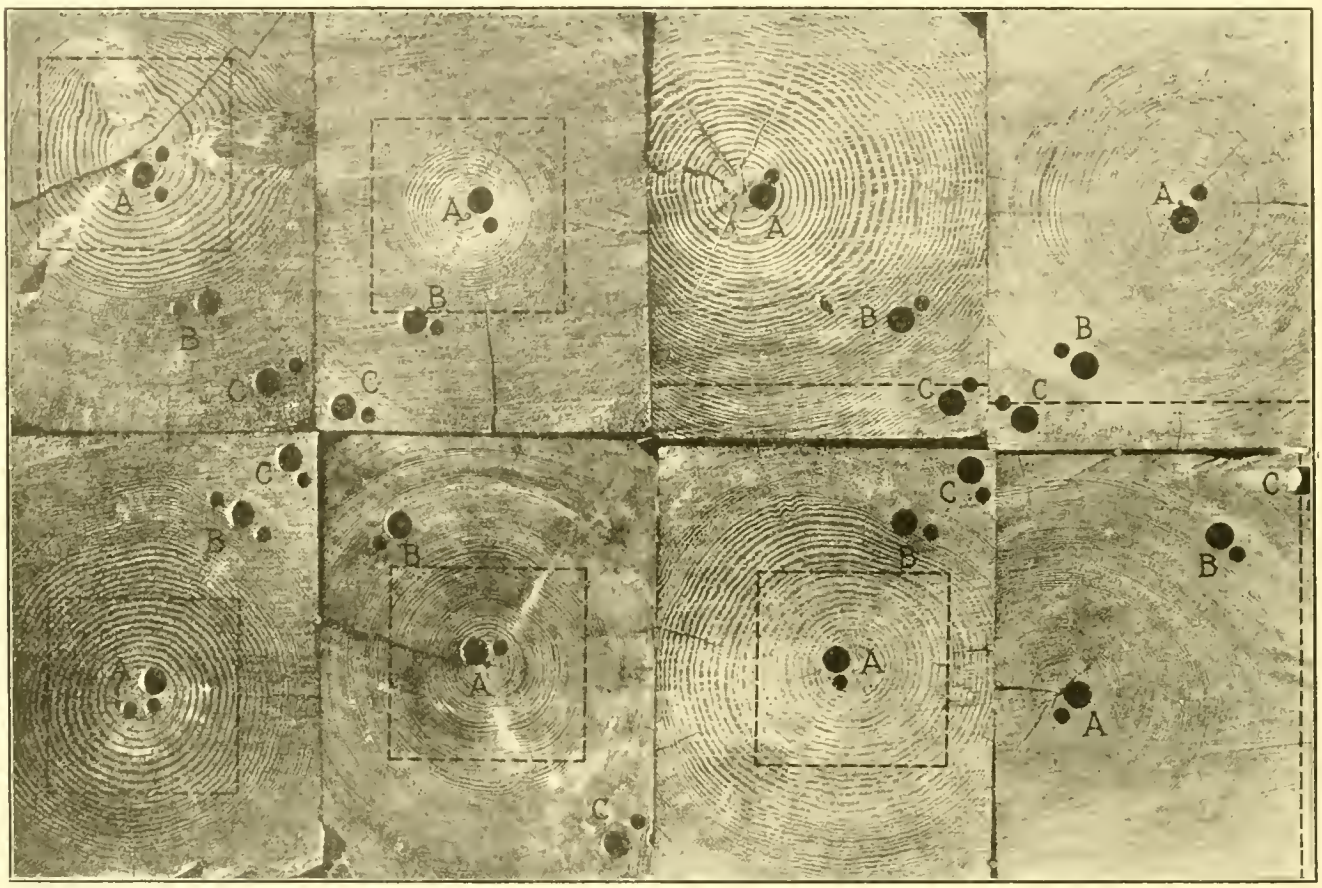


Fig. 7 New Selected 12 in. by 16 in. Beams

A	B	C	A	B	C	A	B	C	A	B	C
Resin, Per Cent											
14.6	2.7	1.6	12.2	2.4	2.9	34.7	14.1	2.6	13.1	14.1	2.6
12.3	3.0	2.4	8.6	3.2	0.8	12.3	3.0	2.4	7.5	11.3	1.1
Air Dry, Lb. per Cubic Feet											
37	42	37	36	39	37	46	57	61	40	44	34
34	36	30	37	42	33	39	45	36	42	55	50

[1] Bulletin No. 13, U. S. Division of Forestry, p. 13.

[2] Berichte der deutschen botanischen Gesellschaft, vol. 29, 1912, p. 704; Mycologisches Centralblatt, vol. 1, 1912, pp. 138 and 166

that besides being saturated with resin this is nearly all summer wood.

The ideal specification consists undoubtedly of a clear description of the qualities required. In structural timber these are strength and durability. With these qualities defined attributes, such as botanical variety, location of growth or grading, lose their importance. The limits of strength can be easily given, but less easily determined, without destroying the material. The density is probably a sufficiently close index of strength for commercial purposes and the percentage of resin of durability.

Both the resin and the density can be conveniently found by boring half-inch holes into the end of the beam, collecting the chips, drying and weighing them, extracting the resin with benzole and weighing it. Cuban or North Carolina pine with 10 per cent of resin is apparently as resistant to fungus as Longleaf pine with the same percentage of resin. Heart without resin is not a saving quality.

The percentage of resin in the sound centers of rotted beams taken from a mill was determined in order to get an idea of the amount required to stop fungus growth under ordinary mill conditions (see Fig. 7). In rotted beams of the poorest of hard pine there is generally a sound center which contains more resin than the remainder of the section. Sometimes it is not bounded by the growth rings but is very irregular, the cause being that resin has been irregularly deposited in the section owing to knots or injuries to the tree. The limits of the sound centers are frequently not the same as those of the heart wood.

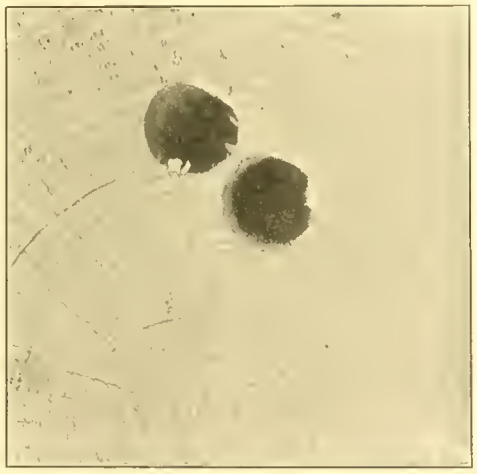


Fig. 8 Showing how Holes in Columns serve as Passageway for Fungus

It is apparent that the limiting amount of resin which is just sufficient to stop the fungus is in the neighborhood of 3 per cent. The limiting power of resin is undoubtedly not absolute but varies with the moisture, variety of fungus and time of exposure. Therefore, it is safe to assume that a mill beam should have not less than 5 per cent of resin throughout successfully to withstand fungus under ordinary conditions of dampness and allowing a reasonable factor of safety. Dye houses and paper mills would probably require more.

In order to determine the distribution of resin in timber of average good quality several sections from beams now being supplied for factory construction were analyzed. Part of these are shown in Fig. 7. The large holes were for samples for resin analysis, and the small ones for density determinations. The material was mostly heart wood and the price paid for it was $59 per 1000 ft. board measure. None of the sections have 5 per cent of resin throughout. Three would come within this limit by cutting off about 10 per cent and the remaining five would require a reduction of about 75 per cent, as shown by the dotted lines.

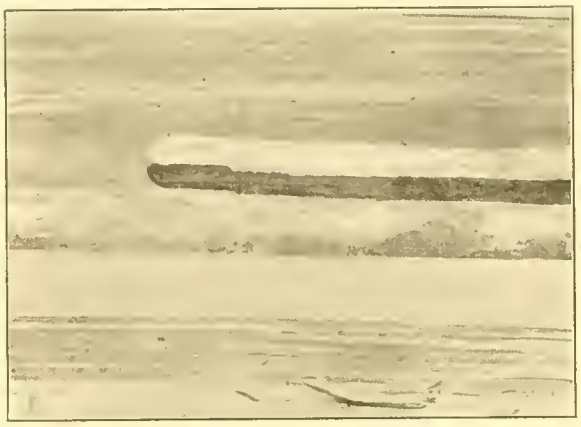


Fig. 9 Column shown in Fig. 8 split to show Fungus

If it could be logically assumed that better material could be bought by increasing the price in proportion to the reduction of the cross-section necessary to obtain the required 5 per cent of resin, $115 per 1000 ft. would be indicated. From such figures as I have been able to obtain this price is not far out of the way for such selected material in large sizes, and even at that price it is doubtful if a sufficient amount for a factory could be had in the required sizes. This indicates that hard pine with sufficient natural resistance to withstand fungus unassisted is out of the question at prices that compare favorably with other forms of construction.

Low power of resistance to fungus in the timber is frequently the last cause to which a serious dry rot outbreak is charged. Ventilation is generally the first preventative measure suggested. Dry wood which is kept dry is undoubtedly incapable of fungus infection but ventilation does not necessarily cause drying. Wood will become dryer or wetter in proportion to the relative humidity of the air; therefore, timber ventilated with moist air will have its rate of rotting accelerated if it is of a susceptible variety. Moreover the susceptible varieties absorb moisture more rapidly than those which are more resistant to fungus.

A heavy coat of paint may accelerate or retard the

rate of rotting, depending upon whether it prevents wood from absorbing or giving up moisture. The question of primary importance is whether the wood is resistant or susceptible to fungus.

Holes through columns and narrow openings between beams encourage fungus more frequently than they prevent it. One of the reasons given for bored columns and double beams has been that they prevent dry rot, and considerable importance has sometimes been given to this feature.[1] Undoubtedly columns with holes through them and thinner beams would dry out

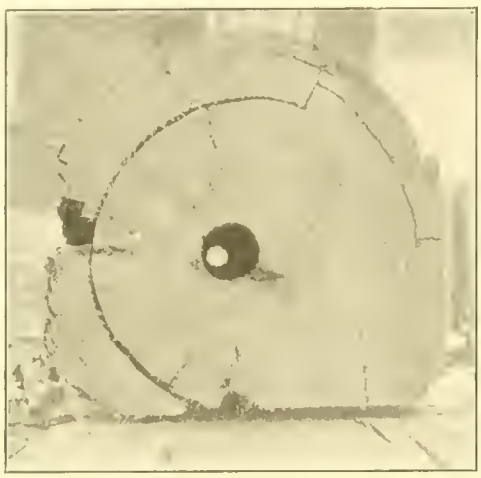


Fig. 10 Example of Bored Hard Pine Column badly rotted after Two Years

quicker, if given a chance to season, but the common custom of boring green or wet columns just before they are put in place in the building and using moist lumber for double beams leave ideal places for the growth of fungus, since the air in the openings is saturated with moisture. Holes in the columns are also objectional since they form a convenient passageway for the fungus to pass rapidly from floor to floor before the building has dried out. Fig. 9 shows a section of a bored pine column split in two with fungus growing through the hole; the column was not deeply attacked as can be seen from the photograph of the cross-section, Fig. 8. The hole is inefficient in preventing rot if the material of the column is susceptible, as can be seen from Fig. 10, which shows a section of a bored column badly rotted. Fig. 11 shows fungus growing in the opening between double beams, the front half of the beam having been removed.

In many old mills hard pine timbers are found to be sound after years of service in moist air. A careful examination will generally reveal the fact that these timbers are resinous Longleaf pine, practically no longer obtainable. There is no more reason for supposing that the nonresinous hard pines now in common use would prove as resistant than there is expecting moist hemlock or birch to resist fungus. There is still available for present requirements in mill construction sufficient hard pine of suitable size and strength. It remains to supplement its lower natural resistance with proper antiseptic treatment.

In conclusion, the following summary may be given:

a The percentage of resin in hard pine can be taken as an index of its power of resistance to rot, 3 to 5 per cent being the lower limit.

b Hard pine lumber 12 in. sq. or larger is not obtainable in quantities with sufficient natural resistance to withstand fungus in a moist location.

c Holes through columns, narrow spaces between beams and hollow spaces in floors or roofs are of little value in preventing rot, and often serve to spread it rapidly to all susceptible material.

d The only hard pine, which is now obtainable in suitable quantities, is not safe to use for the important parts of a mill without antiseptic treatment.

DISCUSSION

E. M. Bates. I would like to ask Mr. Hoxie how far the action of preservatives prevents this fungus growth inside of the beams? Does the treating of the pine timber with one of these preservatives until it is thoroughly saturated on the outside lead to conditions where dry rot can start on the inside? In other words, is the life of that timber dependent upon the wearing out of this water-proof surface on the outside? Also has he reached any conclusion as to the most effective method for treatment?

A. W. Thompson. I would like to ask what would be

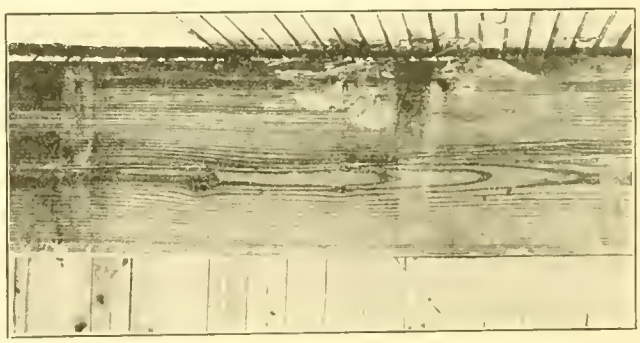


Fig. 11 View showing Fungus between Double Beams, Front Beam having been removed

the probable effect of carbolineum on material in an average mill, with the ordinary humidity, where artificial heat is used? Also what is the best practice as to painting timber? It has been the general impression that it is best to let them remain unpainted for a year or two after they are put into the mill.

A. M. Ernst. Must these preservatives be applied under a vacuum in order to secure their efficiency? Should timber put into the ground, such as fence posts, be coated wet, or is it absolutely necessary to have it dry to put on the preservatives?

Charles H. Bigelow. The author speaks of a number of mills having to be reconstructed; how much danger has there been of this? I did not realize that the danger was coming up so strong. There is, however, another thing to be con-

[1] Engineering News, Vol. 62, 1909, p. 620.

sidered, namely, the number of knots in the timber we get nowadays. I had occasion to look for some timber where Longleaf pine had been called for and something was supplied which was said to be "just as good" but I noticed that the timber was full of knots; the knots of course take up the strength. The reference to the matter of dry rot brings to mind an old house I knew of in Salem, Mass., which is over 100 years old. I do not know what the timber is but it is eaten away on the side with longitudinal tunnels running out in little holes, yet most of the timber is as sound as it can be.

C. J. H. Woodbury. I am very glad Mr. Hoxie has emphasized the importance of contagion from the germs of decaying timbers. Only within the last month, there were two instances in my practice in which I was obliged to insist that decayed timber should be burned at once, to get it out of the way quickly, because if it were cut and stored elsewhere where it could be used for kindling, it would injure other sound timber which composed part of the storehouse. The decay in the solid ends of beams in mill walls was considered more than 30 years ago by the late William B. Whiting, by his advocacy of ventilating the ends of such timbers, at a time when the usual practice sealed them up so as to make a better architectural appearance on the inside. There is one type of defect, not so prevalent as a broken beam or collapsible column, but germane to the general scope of this paper and that is a basement floor which is subject to rapid decay, which difficulty has been conquered by the use of air slacked lime. In a mill at Claremont, N. H., a basement was blasted out of a seamy rock which was teeming with water leaching from the canal above and it was covered by a floor which lasted for many years, merely by using the pieces of rock which had been blasted away as a sub-foundation for the floor and providing suitable drainage; upon this a quantity of air slacked lime was placed and the floor was sound at the time of my last information. Another instance occurred in a mill in Waltham over a cement basement floor put down in 1854 and the beams on which the floor rested for nailing strips, decayed to a brown powder, but the spruce planks painted on the bottom side with hot coal tar resisted decay. These lasted while several hardwood top floors were worn out and removed, and were found 35 years later when the whole floor was removed. In a machine shop in Philadelphia, the basement floor was laid on spent molding sand with a space of 2 in. between the top grade of the sand and the inside of the floor. Holes were bored in this underfloor and the space filled with melted resin poured through funnels; this floor lasted many years.

E. V. French. I want to emphasize what is really the revolutionary character of the information which Mr. Hoxie has brought to us. He shows that practically all of the old requirements as to timbers cannot be used safely today so that new specifications must be made in keeping with the new facts. Most of the old slow growth timber with its large percentage of resin is exhausted. It will be several generations before timber of this kind will grow again, so that for many years inferior timber which is susceptible to dry rot will have to be used. To make such timber safe Mr. Hoxie's data show that it must be treated with some preservative to avoid rapid decay. It is, of course, feasible in new work to use timber which has been treated, but this is only a part of the problem, for with the increase of humidity in old mills, due to the modern manufacturing requirements, timbers which have remained sound for years have decayed rapidly. Recently in a mill 75 years old, white pine beams, which must have dried out thoroughly years ago, were found to be seriously impaired by dry rot. The cause was evidently the material increase in the humidity maintained in these rooms in recent years. This condition may be very serious from the fire standpoint. We have laid great emphasis on the slow burning character of plank and timber construction, but a beam with its center decayed may have but a thin shell of sound wood which will be weakened after a short fire and allow large sections of floor to fall. We do not wish to raise fears, but we must recognize that in these directions there are new conditions of vital importance affecting all such construction.

Charles T. Plunkett referred to the following statement of the author: "The question of primary importance is whether the wood is resistent or susceptible to fungus," and called his attention to the fact that he had not suggested any method for use in judging whether it is susceptible or resistant.

The Author. In reply to Mr. Bates, sound wood thoroughly treated with a suitable antiseptic material will probably be found immune from fungus with ordinary mill conditions. Dry rot undoubtedly enters the timbers from the outside, but a very common condition is that in which the timber is already deeply infected when treated. The fungus inside the wood is not destroyed by the thin superficial brush coat. If the lumber is heated sufficiently long in a bath of hot material, the heat may destroy living fungus which is beyond the penetration of the compound. As to the most effective method for treatment, no conclusion has yet been reached. Investigation is still under way, and I hope to be able to present something at a later date. The problem of mill timber is quite different from railway ties or posts.

Answering Mr. Thompson, carbolineum has shown good results when applied to telegraph posts and mine timbers. I should, therefore, infer that it could be expected to act satisfactorily on mill beams where conditions are not so trying. This material in common with other coal tar compounds has the disadvantage of increasing somewhat the combustibility of the timber and leaving a black, greasy surface difficult to paint. Paint on a dry, uninfected beam would tend to keep it dry and sterile and therefore be an advantage. With a moist infected beam the opposite would be the case.

In answer to Mr. Ernst, the thorough treatment of timber by the vacuum process is without doubt desirable for fence posts in order to secure the longest life. With wet or already deeply infected material, I imagine the sterilizing and drying effect of a hot bath would increase the efficiency of the treatment and the increased penetration caused by the vacuum would probably secure a greater permanence. Little service could be expected from any antiseptic superficially applied to wet, diseased wood.

Replying to the question of Mr. Bigelow, as to the extent of the danger from dry rot, Mr. Hoxie stated that he had investigated about a dozen cases of dry rot in the past three years; the damage resulting had been found to vary from a few hundred dollars up to $90,000. Referring to the old house in Salem, Mass., mentioned by Mr. Bigelow, Mr. Hoxie stated that the condition mentioned is probably worm eaten sapwood.

Mr. Hoxie stated that it was probable that the fungi, which Mr. Woodbury mentioned, as dangerous in the decayed timber, were those frequently found in timber lying on the ground, not the dry rot which is proving destructive of mill frames. Referring to the use of hot rosin under the floor quoted by Mr. Woodbury, Mr. Hoxie stated that the heat might have value in sterilizing the lumber. A space around beam ends in walls can admit moist as well as dry air. If the wall is cold and the air in the room contains a high percentage of moisture, the ventilating space will do more harm than good.

In reply to the criticism of Mr. Plunkett, concerning a suggestion of methods for use in judging whether timber is susceptible or resistant, Mr. Hoxie stated that this matter was discussed quite fully in his paper. The percentage of resin appears to be a reliable index of the power of resistance.

CONTRIBUTED DISCUSSION

Hermann von Schrenk[1] (Abstracted). The author has reached some rather startling conclusions, which, briefly stated, are as follows:

a The percentage of resin may be taken as an index of its power of resistance to rot in any one particular piece of hard pine timber.

b The present hard pine timbers obtainable in the market are practically all (as he designates them) "non-resinous."

c All of the pine timber now available has a low resistance to decay, and cannot with safety be used in factory buildings without preservative processes.

The conclusions are so at variance with the actual facts in the case that I deem it necessary to call attention to the obvious errors in the paper.

In regard to resin as a factor in preventing decay, in view of the fact that the author's major contention is based on the relation between resin and decay resistance, one would assume that there would be a good basis for such a statement. The only proof which the author presents is a cultural test made with two pieces of pine wood. He also calls attention to the resin content of some decayed beams shown in Fig. 6. To one familiar with the behavior of fungi, the cultural proof submitted is of no value whatever. The reasons fungi grow on one piece and not on another may be due to the moisture content, to the density of the wood fiber, to the presence or absence of various compounds, and to many other factors not referred to by the writer. The decayed beams shown in Fig. 6 are splendid examples of decayed sapwood, and I have no hesitation whatever in saying that the resin content of the particular wood which decayed probably had very little to do with the fact that this sapwood did decay.

Numerous investigations have been made from time to time with relation to resin and fungus activity. Personally, I am of the opinion that the only function which resin has with respect to fungus growth is to act as a waterproofing material. A piece of pine wood having 10 per cent resin would be very resistant to moisture. Resin of itself is not an antiseptic. This may be illustrated by the fact that even in the most resinous trees wood-destroying fungi grow with the greatest ease. I have shown in numerous instances[2] that one of the first steps in the attack of coniferous wood, containing considerable percentages of resin, is the liquefication of the resinous substance, which advances in front of the growing fungi, and in frequent cases drips from old knots. This subject might be discussed at length (note for instance the high decay resistance of comparatively non-resinous woods like cypress and redwood). One quotation, however, will suffice. Tubeuf, in his treatise on Diseases of Plants, page 62, says, "Resin is in itself not antiseptic," etc. The only so-called antiseptic function which can be ascribed to resin is the physical quality of preventing the entrance of fungus spores and the physical power to prevent the entrance of water. Mr. Hoxie on page 24 refers to a possible analogy between tannin and resin. It seems hard to understand why, if tannin is a preventive for fungus attack in oak trees, resin should exercise a similar function in pine trees. The author's citation of volume 29 is also unfortunate, in view of the fact that no mention whatever of tannin is made in this article. It is unquestionably true that recent experience in various mill construction buildings has shown an increasing percentage of timbers infected with dry rot. I consider it wholly unnecessary, however, to ascribe this to such a problematic factor as the resin content. I have personally examined a good many of the recent cases, and invariably find that where such decay has taken place it has been in timbers having a high percentage of sapwood. Mr. Hoxie shows this in a very striking manner in Fig. 6. It has been recognized for many years that the relative resistance to decay of sapwood and heartwood is very marked. Sapwood decays rapidly and heartwood comparatively slowly. This is of course universally true of timber in which there is a marked distinction between heartwood and sapwood. This is not the place to discuss the reason for this relative resistance. It will be sufficient to point out that it is the *sapwood* factor in timbers which has given rise to recent difficulties, and not the resin factor. The proposal of the author to consider the resin percentage as a standard (p. 25), and his attempt to figure the value of a piece of timber use on the per cent of resin as a basis, is so extreme, that I hardly consider it worthy of refutation. At best, the engineering profession should go slowly before accepting so radical and unproved a suggestion, based as it is upon a comparatively small number of laboratory experiments, which, so far as can be judged from the paper in hand, failed to take into consideration the numerous conflicting factors usually eliminated in such cultures.

The second point brought out by the author is that the hard pine timbers now available are practically all non-resinous. I have looked through the paper carefully for some statement as to what the author means by "non-resinous" pines. The impression given by the paper is that years ago there were a lot of timbers which come under the group of resinous timbers, but that these have now disappeared.

A possible change which might have taken place in the resinous character of the pines during the last ten or fifteen years, which suggests itself to me, is that during that period of time many of the long-leaf pines have been tapped for turpentine, and this possibly may have given rise to an im-

[1] Member of firm, von Schrenk and Kammerer, Consulting Timber Engineers, St. Louis, Mo.

[2] Diseases of Trees, Year Book of Agriculture, 1900, p. 204, plate 23. See also writings by Tubeuf and Hartig.

pression that removing the turpentine from the pine tree makes it less resinous. This is certainly true so far as certain portions of the sapwood are concerned, but it is not true of the heartwood, as evidenced in the report of the Forestry Service Bulletin No. 8.

The resinous materials of the pine tree, which are removed from the tree during the turpentining operations, come from the liquid portions contained in the sapwood resin canals. I am inclined to believe that Mr. Hoxie drew his conclusions from a comparatively small number of sappy pieces; at least I would characterize his generalization as decidedly without foundation. The variable in the resin content of pine timbers is obviously very great, and this is well shown in the analysis which he presents in Fig. 7.

Mr. Hoxie admits that there are still available four species of pine in the South, but he makes the very strong statement that hard pine lumber 12 in. sq., or larger, is not obtainable in suitable quantities without antiseptic treatment. It may be of interest to call attention to the quanity of pine timber still standing in the Southern States. According to the last report,[1] of the United States Bureau of Corporations for 1913 there are still standing in the Southern States 384,000,000,000 ft. of yellow pine timber, which the Bureau of Corporations classifies into longleaf pine and shortleaf pine. Of the 384,000,000,000 ft., 232,000,000,000 ft. are longleaf pine and 152,000,000,000 ft. are shortleaf pine. Referring to the eastern part of the country, it may be of interest to note that the amount of yellow pine still standing in the Southeastern States is as follows, in billions of board feet:

	Longleaf	Shortleaf
Alabama	25.6	12.4
Florida	58.2	0.9
Georgia (part)	18.5	13.2
S. Carolina (part)	4.6	14.6
N. Carolina (part)	2.9	22.7

Assuming now that the longleaf pine available is typical longleaf pine, no proof has been brought forward by the author of the paper that this is less fit for structural use than it was 15 years ago. The resin factor, I believe, can be disregarded entirely. The difficulty of obtaining such longleaf pine timbers as were available 15 years ago is, as the writer admits, largely a matter of specifications. On p. 22 of the paper the author criticizes the American Society for Testing Materials' specification for adopting the terms "longleaf pine" and "shortleaf pine," going to the extent of characterizing this specification as "arbitrary." I would call attention to the fact that the classification "longleaf" pine and "shortleaf" pine is universally adopted not only by scientific authorities,[2] but also by the lumber trade. Reference has just been made to the classification adopted by the United States Bureau of Corporations, in which all southern lumber pines are classified as longleaf pine and shortleaf pine. I would furthermore call attention to the fact that the largest percentage of yellow pine lumber is today being manufactured under the rules of two organizations, the Georgia-Florida Sawmill Association (annual cut about 800,000,000 ft.) and the Yellow Pine Manufacturers' Association (annual cut about 4,500,000,000 ft.). Both of these associations divide all yellow pine into longleaf and shortleaf pine (see their standard grading rules).

It was for the reason that these commercial classifications are practically standard that the American Society for Testing Materials indorsed them. The problem of distinguishing between these two grades is a difficult one. I thoroughly concur with Mr. Hoxie that the line of demarcation between the two is very vague, and almost impossible to establish with any degree of accuracy. The American Society for Testing Materials suggests that the distinction between the two be based on the density, that is, on the number of growth rings per inch. This distinction may not be the best, but can be used when liberally interpreted where a botanical distinction is out of the question. Attention is furthermore called to the fact that the distinction on the basis of density, made by the American Society for Testing Materials, was largely from the standpoint of strength. No specific mention is made as to lasting power, because that factor was taken care of in the specification for bridge materials by separate clauses. Attention is called to the standard specification for structural timber adopted by the American Society for Testing Materials in 1907,[1] in which for No. 1 longleaf pine stringers the specification calls for timbers which show *not less than* 80 *per cent heart on each of the four sides,* measured across the sides anywhere in the length of the piece. For caps and sills the specification calls for 85 *per cent heart on each of the four sides.* In other words, the American Society for Testing Materials' specification calls attention, first, to the necessity of getting denser timber, and to timber free from sap. Similar specifications are in force in the American Railway Engineering Association. The rule quoted by Mr. Hoxie on p. 22 as prime, practically says the same thing. It is somewhat surprising, therefore, to read below this: "This specification for prime quality loses most of its force when applied to pine of the type shown in Fig. 4." Reference to Fig. 4 shows the upper timber to be almost wholly sap, and the lower over 50 per cent sap. Certainly neither of these two pieces could by any possible means come within the specification "prime," or the American Society for Testing Materials' specifications for longleaf pine. The same is true of all of the figures shown on Fig. 6, not one of which would begin to fulfill either of these two specifications.

The chief trouble with a good many of the failures has doubtless been that the purchaser has not given the timber the proper inspection, because with the specifications available, both of the lumber manufacturing organizations and the American Society for Testing Materials, I can see no excuse whatever for anybody putting timbers such as shown on Fig. 6 into a mill of any sort. My main contention is that the writer of the paper has missed the chief point in connection with this discussion, and that is that the important factor in the lasting of yellow pine in buildings is not the resin content of the timber, but the percentage of sapwood allowed on such timbers. In a recent building failure, which I had to examine personally, in which a large number of timbers had failed, the failure was in timbers with a high

[1] Dept. of Commerce and Labor—Bureau of Corporations The Lumber Industry. Part I, Standing Timber, p. 76, 1913.

[2] From the United States Forestry Service, Bulletin No. 108, on Tests of Structural Timbers, 1912, concerning southern yellow pines: "The term 'southern yellow pine' is applied collectively to practically all of the pines of the Southern States which are manufactured into lumber. On the market the manufactured lumber is divided into two classes, longleaf and shortleaf. Material with more than 8 or 10 rings per inch, and containing a comparatively large amount of summerwood and less than 30 per cent. of sapwood, is called longleaf pine; while material with fewer than 10 rings per inch, slow-growing material that is light in weight, and which contains much sapwood, is called shortleaf pine. Commercially, therefore, the terms 'longleaf' and 'shortleaf' are descriptive of quality and have little botanical significance."

[1] Page 191.

percentage of sapwood, and in the practically all-heart timbers there was only one case of decay, and that one was very slight.

If one specifies longleaf pine timbers for buildings, and strictly adheres to the specification, limiting the amount of sapwood, one will find that the timbers available will give just as good service, from the standpoint of length of life, as those furnished in the past. I agree entirely with the author when he says that timbers of the type shown on his Figs. 3, 4 and 6 should under no circumstances be used in factory buildings without preservative treatment. I believe, however, that he has given an entirely wrong picture when he accuses all longleaf pine timber of lack of decay resistance, when such lack is due largely to the amount of sapwood on the timber.

In closing this criticism, I venture to add that many a producer of lumber has been remiss in furnishing sappy timber under a heart specification, and if there is one point which ought to be emphasized with the greatest strictness on the part of engineers, it is that they shall refuse to accept inferior timbers such as those shown on Fig. 6. There has been a marked change in the nature of the timbers manufactured in the southern yellow pine field during the past seven or eight years. When southern yellow pine was first introduced in northern markets, it was almost wholly strictly longleaf yellow pine. The older buildings were almost without exception built of this heart longleaf yellow pine. The early shipments of longleaf pine usually came from Georgia and Florida. During recent years the pine forests of the more northern states have been drawn upon, and large quantities of timbers are manufactured in North Carolina, South Carolina and Virginia. Most of these are shortleaf and loblolly pine, in which the percentage of sapwood is very much higher than in the true longleaf pine. I have had numerous occasions to protest against the acceptance of sappy shortleaf timbers (shortleaf and loblolly pine) for construction purposes, and frequently it has been difficult to make the manufacturers of this class of lumber understand that they will not be acceptable to the engineer where both strength factors and lasting qualities are desirable. Too much stress cannot be laid upon the necessity for care in not only specifying, but also inspecting every piece of pine timber intended for a building in which both strength and lasting qualities are factors. The poor experience obtained in many recent instances, and specifically those to which Mr. Hoxie refers, are without doubt due to the fact that in these particular buildings sufficient care was not exercised in seeing that these inferior pieces were excluded. I have repeatedly criticized the lumber manufacturers for their failure to live up to their end of the contract. I have also repeatedly criticized the laxity which exists among engineers and architects who allow the contractor or lumber salesman to give them sappy loblolly or shortleaf pine where longleaf pine has been specified. It is highly desirable that the very inspection which the writer of this paper despairs of should be strengthened, and that wider publicity should be given to the caution to use only heart timbers, and to be sure that you get heart timbers when you buy them.

Summarizing the chief points in this criticism:

a Resin cannot be taken as an index of the natural resistance to rot of pine timbers.

b There is no basis for the statement that all pine timbers now available are non-resinous.

c Longleaf pine timber is still available in large quantities for acceptable factory construction.

d Where specifications are written for such factory construction, the greatest stress should be laid upon the percentage of sapwood allowed, because it is the sapwood and the sappy pieces which decay. All recent cases, so far as known to me, have been cases of decay of sapwood timbers, and not of all-heart timbers.

e No timber should be put into a building without rigid inspection, to make sure that only such timbers are furnished as are strictly in accord with the specifications.

THE AUTHOR. Laboratory experiments have been by far the least important factors in my conclusions as to the effect of resin in retarding dry-rot fungus. Beams which have rotted in place seriously in several mills under average mill conditions have been used for most of my experiments. Undoubtedly the most important antiseptic function of resin is its waterproofing action. Further observations are without doubt desirable.

Three references will be found in foot notes on page 24; the last reference shows tannin to be the cause of the immunity in the oak flooring mentioned in the first. This is a discussion of the qualities of pine that rots and of pine that does not rot, not of pine versus cypress or redwood. It is also a question of diseases of mill beams, not diseases of living trees.

Most of the material shown in Figs. 4 and 6 is the conventional longleaf pine and fills the requirements of Bulletin No. 108 of the U. S. Forest Service, as quoted. I must differ with Dr. Von Schrenk as to the sapwood; the percentage is not large and more heartwood than sapwood has rotted. The beam shown in the lower part of Fig. 4 must be longleaf pine, as it is fine-grained; it must be prime quality as it is nearly all heartwood. Nevertheless it is unquestionably rotted. After a timber has rotted it is very easy for almost anybody to say that it was poor material, but it is frequently much more difficult to predict what it will do before it has rotted.

Dr. Von Schrenk states that such timbers as those shown in Figs. 3, 4 and 6 should under no consideration be used without antiseptic treatment. If so, as most of these are conventional longleaf pine, of prime quality, it is logical to infer that all hard pine timber would require antiseptic treatment to assure its lasting qualities.

I think I have not said that there has been any change in the true longleaf pine except the use of its name for other varieties. The statistics quoted, giving an estimate of the conventional longleaf pine standing in the South, do not prove that it will be found more resistant to decay when it is cut into timber than the present lumber supply, which is admittedly less resistant than that of former years.

In the following Dr. Von Schrenck agrees with my statements:

a Hard-pine mill frames erected within the last seven or eight years show greater tendency to rot than those erected earlier.

b The name longleaf pine now has an arbitrary meaning without botanical significance.

c The distinctions between lumber which is conventionally called longleaf and that which is conventionally called shortleaf are vague; much is left to the generosity of the lumber dealer and

the good judgment of the inspector, and lumber dealers are frequently without generosity and inspectors without judgment, accentuating the need of concise specifications.

d True longleaf pine is as good now as it ever was.

e The general run of southern pine is much poorer now than in former years.

But we disagree as to the value of the percentage of resin as an index of the resistance of hard pine to dry rot in mill timber; as to whether or not heartwood is a guarantee of fungus immunity; and as to the necessity of general antiseptic treatment of hard pine for mill frames.

I am not trying to demonstrate that resin as a waterproofing agent, or otherwise, retards the progress of rot. This has been a matter of common knowledge for centuries. What I do want to determine is how much resin is necessary to retard dry rot sufficiently in mill timber to make it reasonably safe for use in mill construction with average conditions. I further want to know what the chances are of getting such resistant lumber from the present lumber market. If it is not practicable to be certain of getting such timber by methods in general use, I want to decide upon an antiseptic treatment which can be practically applied and which will render the poorest varieties of timber sufficiently reliable to be used with safety, so that the mill owner may be reasonably assured that his expensive structure will not be seriously damaged by dry rot in a few years and that a rotted column or beam will not cause an accident which may kill his employees. Any assistance which Dr. Von Schrenk can offer along this line of endeavor will undoubtedly be appreciated by the mill engineers of the country.

MEETINGS

MINNEAPOLIS—ST. PAUL, NOVEMBER 5

Sixteen members of the Society met at the Hotel St. Paul, St. Paul, Minn., on November 5, for the purpose of organizing in that vicinity a branch of the Society similar to those already in existence in ten other cities. The meeting was in charge of Max Toltz, as temporary chairman, and E. J. Heinen, as temporary secretary, and a great deal of interest was shown in the formation of this organization. The election of officers for the year was as follows: the two temporary officers were made permanent, the duty of treasurer being added to that of secretary, and Mr. C. L. Pillsbury was chosen as vice-chairman. The name of the organization was definitely decided upon as the "Minnesota Branch of The American Society of Mechanical Engineers."

Plans for the Spring Meeting of the Society, which is to be held in the Twin Cities, as decided at the last Spring Meeting in Baltimore, were also set on foot by the election of an executive committee consisting of the following members: Oliver Crosby and Henry LeR. Brink, of St. Paul; John J. Flather and Wm. H. Kavanaugh, of Minneapolis; T. W. Hugo, of Duluth, and Messrs. Toltz and Pillsbury, members ex-officio.

PHILADELPHIA, DECEMBER 10

The meeting of the Society in Philadelphia, on December 10, was preceded by a dinner at the Engineers Club, at which the Committee on Meetings in Philadelphia entertained the speakers of the evening, Messrs. Morris Llewellyn Cooke, Mem.Am.Soc.M.E.; J. B. Lichtenberger; Lewis H. Kenney, Mem.Am.Soc.M.E.; Calvin W. Rice, Secretary of the Society; Henry Hess, Manager of the Society; and John Price Jackson, Mem.Am.Soc.M.E., and Commissioner of Labor of the State of Pennsylvania.

The first paper of the evening was read by Mr. Kenney, who chose as his subject, How far shall Judgment be exercised in the Interpretation of Engineering Specifications. The author is draftsman-in-charge of the machinery division of the Philadelphia Navy Yard. Mr. Cooke, who is director of the department of public works of the City of Philadelphia, read the second paper, and Mr. Lichtenberger, lawyer and lecturer on business law at the University of Pennsylvania, the concluding paper. An interesting discussion which was participated in by Messrs. Rice, Hess, Jackson, Henry H. Quimby, Thomas C. McBride, Mem.Am. Soc.M.E., and Inspectors Wheeler and Willits, closed the program.

ST. LOUIS, DECEMBER 13

The annual meeting of the St. Louis branch of the Society was held December 13, 1913, at the Mercantile Club. Thirty-eight members and guests were present, Prof. E. L. Ohle presiding. John Hunter, a member of the Committee on Meetings in St. Louis, who has recently been elected one of the Managers of the Society, was present and received the good wishes and congratulations of his friends; R. H. Tait told in a few fitting words of the esteem and honor in which Mr. Hunter was held in the engineering profession and said that the St. Louis members felt great pride in the honor that had come to one of their number. Mr. Hunter in reply reviewed some of the important incidents in his career on both land and sea, drawing attention to the great strides that have been made in steam engineering during that period, especially in steam turbine units.

Mr. Gustafson, superintendent of the Rankin School of Mechanical Trades, gave an interesting account of his trip in Europe last May, when he investigated the important trade schools on the Continent. He said his work was greatly facilitated by the assistance he received from Prof. Conrad Matschoss of the Verein deutscher Ingenieure, whom he had previously met when on a visit to this country last spring. H. Wade Hibbard, Mem.Am.Soc.M.E., gave an interesting account of the Annual Meeting of the Society, and urged all who could to attend these meetings in the future.

BOSTON, DECEMBER 18

A joint meeting of the Boston Society of Civil Engineers, and the Boston sections of the American Institute of Electrical Engineers and of this Society was held at the Engineers Club, the program being in the hands of the Electrical Engineers. Mr. B. A. Behrend, Mem.Am.Soc.M.E., gave an illustrated lecture entitled, A Great Engineering Disaster and the Lessons Learned Therefrom. The talk was a very entertaining and profitable one.

NECROLOGY

VICTOR HUGO

Victor Hugo was born at Kingston, Ontario, November 20, 1873. He was the son of T. W. Hugo, Mem. Am. Soc. M. E., who in 1881 moved with his family to

Duluth, Minn. Victor Hugo received his engineering education at the University of Minnesota, from which he was graduated in 1896 with the degree of M. E. He began his career as assistant to his father, consulting mechanical engineer of Duluth, in July, 1896, and two years later entered the Chicago inspection force of the Hartford Company. Late in the following year he was transferred to St. Louis, and shortly afterwards was appointed chief inspector of that department. On January 1, 1905 he was promoted to the position of manager, a position he held till his death on January 31, 1913.

ANDREW MARTIN SCHREUDER

Andrew Martin Schreuder was born in Syracuse, N. Y., October 17, 1874. He obtained his early education in the public schools of that city and his technical training at Cornell University, where he was graduated in 1897. He was subsequently connected in various capacities with the Geo. M. Newhall Engineering Company, the Tabor Manufacturing Company and the Woodbridge Manufacturing Company. In 1908 he became associated with the Philadelphia Textile Machinery Company, at the time of his death, January 1, 1913, being its superintendent and chief engineer. He had developed designs for and successfully built and installed a number of the largest dryers in operation and was engaged in the development of dryers for explosives and inflammable materials.

He was a member of the Cornell Club and of the Franklin Institute of Philadelphia.

WILLIAM OLIVER WEBBER

William Oliver Webber was born at Springfield, Mass., January 4, 1856, and was educated at the public schools of Manchester and Portsmouth, N. H., and of New York. He served his apprenticeship at the Manchester Locomotive Works from 1871 to 1874, and since then has served in engineering capacities in the locomotive department of the Boston & Maine Railroad Company; with the Toledo, Peoria & Warsaw Railroad Company, Peoria, Ill.; with the United States Centennial Exposition, Philadelphia, in 1876; in the test department and laboratory of the Chicago, Burlington & Quincy Railroad Company, Aurora, Ill. In 1881 Mr. Webber was made superintendent of the Allen Paper Car Wheel Company, Pullman, Ill., and six years later, commissioner of Abolition of Grade Crossings in Massachusetts. He relinquished this position one year later to accept the superintendency of the Erie City Iron Works. Since 1894 he has been a consulting engineer in the firm of Webber & Smith, Mechanical, Hydraulic and Dynamic engineers, of Boston. He acted as expert in the United States and Circuit Courts.

Mr. Webber had been a member of the Ancient and Honorable Artillery Company since 1884, and engineer officer of the First Brigade Staff, United States Navy, from 1901 to 1904. He was a member of the Boston Society of Civil Engineers, the Society of Colonial Wars, United States Military Institute and the United States Naval Institute. He died January 9, 1913.

WILLIAM H. LEACH, JR.

William H. Leach, Jr., was born in Brooklyn, N. Y., September 4, 1873. He received his technical education as a mechanical engineer at the Massachusetts Institute of Technology, being graduated in 1897. Immediately upon graduation he entered the employment of the Union Metallic Cartridge Company of Bridgeport, Conn. During his fourteen years of service there he acquired an intimate knowledge of many of the manufacturing processes used in the fabrication of the companies' products; he designed machines for manufacturing primers, and for packing them, loading and packing cartridges, machines for weighing powder charges and delivering them into their cartridge shells, loading apparatus for rapid-fire ammunition, etc. His work consisted also of laying out and setting up machines, and systematizing the work in the engineering department. During the last two years of his business life he was research engineer for the company and was considered one of the foremost experts on ammunition in the country. He died in Newton, Mass., September 6, 1913, after an illness of two years.

GEORGE HAMPTON SMITH

George Hampton Smith was born in Pittsburgh, Pa., September 29, 1878. He attended the public schools of Pittsburgh and immediately after graduation from high school entered the Carnegie Steel Company where he was under the direct supervision of James Scott, superintendent of the Isabella and Lucy furnaces of the Carnegie Steel Company, Pittsburgh. His experience covered all phases of blast-furnace work, including the drafting room, and in this manner he gained a wide and thorough knowledge of blast-furnace construction. He was graduated in 1910 from the Carnegie Technical Schools in mechanical engineering and in 1911 was made assistant to the chief engineer under Mr. Scott at the steel works. In this capacity he had charge of practically all the construction and drawing room work in connection with the building of modern thin lined water-cooled furnaces with which he had great success. At the time of his death, May 20, 1913, he was engaged in remodeling the stacks of the Carnegie company's Edgar Thompson works at Braddock, Pa.

Mr. Smith was a member of the Railway Club of Pittsburgh, and president of the Council of Aspinwall, where he had made his home for the past ten years.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

WITH this issue the Foreign Review enters into the third year of its existence. While formerly considerations of space permitted only the abstracting of periodicals printed in foreign languages, it has now been found possible to extend this section of The Journal so as to cover also the proceedings of various engineering societies. The Library of the Engineering Societies receives official publications of 132 engineering societies from all over the world, many of them practically inaccessible to anybody outside of the City of New York. While not all of them contain material of intrinsic interest to the mechanical engineer, there is certainly a vast amount of material presented in a skillful manner, and valuable information on various engineering problems of the day. The abstracting done must of course be kept within the space available for this purpose, but an attempt will be made to have, as far as possible, all the main engineering data contained in the paper or investigated either included in the abstract or fully referred to.

The Review in its new constitution will be divided into two sections: the Foreign Review, and the Review of the Proceedings of Engineering Societies. At the end of the year a common index to both sections will be published. As heretofore, wherever necessary, all values, when quoted in European units, will be given also in corresponding American units, and all the other features of the Foreign Review, such as the Supplementary References to articles previously abstracted, will be retained and extended to the new section as well.

THIS MONTH'S ARTICLES

In the section of Compressed Air Machinery the Meyer flat spring valve for air compressors is described, and is nearly the simplest that can be made. In the next section is shown the Bucherer inhalator-vaporizer working on the principle of the medical inhalator; its interest lies in the fact that with a heavier fuel it uses a larger nozzle which ought to help to avoid clogging of the nozzle; the same vaporizer can be made for kerosene engines with two float chambers.

A German installation for autogenous welding on a very large scale is described; the plant provides enough acetylene to take care of 50 welding burners, some of them of very large size, and has an overall output five times as large as is necessary to light a city of 5000 inhabitants, and *is run by one man only*. Of particular interest is the description of the devices insuring safety of operation. In the Chopovski process for electrical case carbonization is described a method which appears to be as yet only in the experimental stage, but, which, if properly developed will give a process permitting the full control of the thickness of the cementation layer of steel. Refrigeration engineers, particularly those who have to design apparatus for tropical countries, will be interested in the Plank process for increasing the output of CO_2 refrigerating machines working with high condenser pressures. In the section Steam Engineering several interesting devices are described, such as the Gestra valve for blowing off boiler deposits (the author claims that the boiler should be blown off for a couple of seconds every two or three hours); the Eimert battery for increasing the output of firetube boilers without increasing the space taken up by them. In the same section will be found an interesting discussion on the friction of gases against the walls of brick passages based on tests made by the author in a Russian steel plant. An extensive abstract is given of the article by Neumann on the efficiency of the Bone-Schnabel boiler in view of the scarcity of material referring to this new type of steam generator which just now is attracting much attention in Germany.

In the Review of the Proceedings of the Engineering Societies will be found an extensive abstract of Professor Lucke's paper before the American Gas Institute on the still somewhat mooted subject of surface combustion, to which, in connection with the use of the Bone-Schnabel system for boilers, is also devoted the article of Neumann in the Foreign Review section. To the class of papers dealing with the same subject, search for a cheaper fuel, belongs the paper by James Lord on the use of pulverized coal. While it deals mainly with the metallurgical aspect of this problem, in the abstract of the discussion which followed, data will also be found on the application of this new fuel to steam boilers. How to adapt the boiler to the coal available, and in particular the water-tube boiler to Southern highly volatile coal, is the question discussed before the Western Society of Engineers by H. Kresinger and Walter T. Ray, who, by a series of tests show that modified baffling may give very gratifying results.

After the subject of getting heat from the fuel comes that of using it in the most economical manner. In this connection attention is called to the paper on saving of heat units in marine machinery, by H. C. Dinger, before the American Society of Naval Architects. The description of the Power Supply on the Rand, given by A. E. Hadley before the British Institution of Electrical Engineers, describes a large power system selling, on a large scale, compressed air, in addition to electricity, and, among other things, confirms the commercially important fact that compressed air in large quantities can be transmitted to fairly long distances without losses that would make the operation of the system prohibitively expensive.

A rather complete abstract is given of the interesting paper by Prof. A. H. Gibson before the British Institution of Mechanical Engineers on the design of volute chambers and guide passages for centrifugal pumps.

Attention is also called here to the paper of A. H. Sabin on painting structural steel, to be presented before the American Society of Civil Engineers in January 1914; the description of an electric dynamometer designed by Nathan C. Johnson, and articles on the use of lignite coal for locomotives, boiler scale prevention, etc. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

FOREIGN REVIEW

Aeronautics

Numerical Estimation of Longitudinal and Lateral Stability of Airships (*Zahlenmassige Wertung der Längs- und Seitenstabilität von Flugzeugen*, R. Skutsch. *Zeits. für Flugtechnik und Motorluftschiffahrt*, vol. 4, no. 21, p. 281, November 15, 1913. 3 pp., 2 tables. *c*). The author derives certain coefficients for longitudinal and lateral stability of aeroplanes, and gives a table of values of the magnitudes entering into their equations for a large number of monoplanes and biplanes covering practically the entire field of machines of commercial importance. Some data are taken from hitherto unpublished materials, such as original drawings of apparatus which has not apparently been described in print.

Technical Impressions of the Exhibition Flights of Pégoud (*Technische Impressionen vom Schaufluge Pégouds*, F. Ellyson-Edelstein. *Zeits. für Flugtechnik und Motorluftschiffahrt*, vol. 4, no. 21, p. 284, November 15, 1913. 11 pp., 7 figs. *d*). Description of the Bleriot apparatus and starting devices used by Pégoud in his exhibition flight at Aspern (near Vienna, Austria) and Johannistal, Germany, and a very interesting analysis of the methods which allowed him to fly upside down, loop the loop, etc. The author comes to the conclusion that it was the inherent lack of stability of the apparatus used that permitted Pégoud to perform safely all his evolutions, which he could not do unless he had an apparatus conforming to the following conditions: supporting planes of the most simple geometric form; unenclosed, short, rectangular hull with rounded edges; large steering planes; horizontal rudder convex bottomward; a light carriage, and an indifferent position of equilibrium. These conditions, however, are also the typical characteristics of an inherently unstable machine. The author attaches great importance to the demonstrations of Pégoud in that he has not only given valuable data for future constructors of airships, but has shown to the general public that, in the hands of the right men, flight has already become one of the safest means of locomotion.

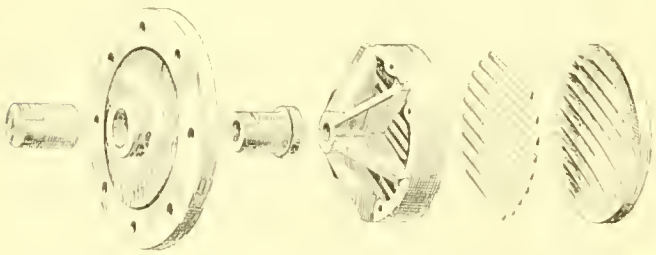


Fig. 1 Myer Flat Spring Valve for Air Compressors

Compressed Air Machinery

The Production of Compressed Air and Its Application in Shops (*Die Erzeugung der Druckluft und ihre Verwendung in Fabrikbetrieben*, A. Wallichs. *Die Fördertechnik*, vol. 6, no. 10, p. 227, serial article not finished. *d*). Among other things, the article contains an interesting description of the *Meyer flat spring valve for air compressors*. The tendency towards the use of light valves began with the successful introduction of the Rogler and Hoerbiger valves, endeavor lately, at least in Germany, having been in the direction of designing the valve as simply as possible. Fig. 1 shows what appears to be nearly the simplest possible design, the simplicity in this case having been attained by the use of a flat spring valve. The "lift" of the valve is effected by the bending of separate lamina, independent of one another. The article states that sufficient data are still lacking as to whether this construction will stand long wear, and especially as to whether the spring lamina will remain air-tight after continued use. The article describes also the latest types of the Hoerbiger valve, the Thyssen valve (four crosswise superimposed springs pressing uniformly on the plate ring valve at four places, while in the free segments are arranged the valve stops), and the Borsig valve, in which the valve and guide are combined through the guide being machined out of, and remaining in permanent connection with, the valve plate itself.

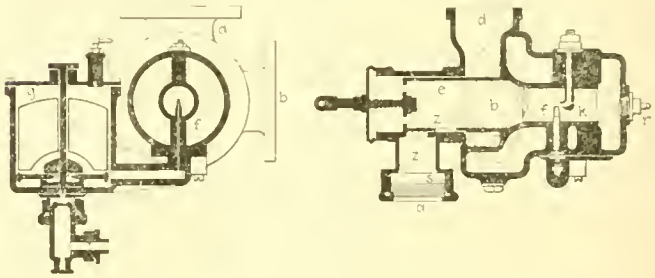


Fig. 2 Bucherer Inhalator-Vaporizer

Internal Combustion Engineering

The Bucherer Inhalator-Vaporizer Patented in Germany (*Der Bucherer-Inhalator-Vergaser (D.R.P.)*, B. *Der Motorwagen*, vol. 16, no. 28, p. 706, October 10, 1913. 1 p., 2 figs. *d*). The Bucherer inhalator-vaporizer may be used with engines of any number of cylinders It is based on a principle materially similar to that of the inhalator used in medicine. The cold atmospheric air enters at *a*, the warm engine air at *b*, and the explosive mixture goes to the engine through the connecting tube *d*. The nozzle *f* communicates with the float chamber *g*, and the nozzle *k* with the atmosphere. The float chamber *g* in its turn is connected with the suction piping by a pipe *r* in a manner such that the same pressure ratio is maintained in both. The fuel is therefore delivered to the fuel nozzle not by the partial vacuum in the suction piping but by the inhalator action of the air nozzle *k*. The fuel liquid drops slowly from the nozzle *f*, and, at the instant of dropping, is torn away by the powerful action of the stream of air coming from the nozzle *k* and atomized in a very complete manner. The action is practically the same as that of a mouth-spray used by street venders of flowers. The cover of the float chamber *g* is provided with an air valve *l* usually closed. If, however, owing to change in the quality of fuel, change of climate, etc., a small adjustment in the quantity of fuel becomes necessary, it is enough to open somewhat the valve *l* in order to change the volume of flow of fuel through the fuel nozzle *f* which is of constant section. The action of the valve *l* is due to the fact that, even though the air entering through it is immediately sucked away along the pipelet *r*, the flow of air through the float chamber produces a small rise in pressure in it, and thus facilitates the injector action of the nozzle *k*. Since the velocity of flow through the nozzle *f* is considerably below that through the usual spray

nozzles, it has to be made of larger cross section; this results in the fact that even in the case of low power engines with a small consumption of fuel, clogging of the fuel valve is made practically impossible. At the same time, owing to the larger cross section of the fuel nozzle, a very small opening of the valve *l* causes quite a substantial change in the flow of fuel, without in the least affecting the inhalator action of the air nozzle. With the usual spray nozzles the use of heavier fuels involved a smaller nozzle (so as to have a greater pressure per square inch in the nozzle); in the inhalator vaporizer, on the contrary, a larger nozzle has to be used. At the same time it is well known that the action of the air nozzle is extremely powerful (the mouth-spray is strong enough to atomize kerosene oil to an impalpable fog), and the powerful blast caused by a nozzle actuated from a running engine is fully sufficient to atomize fuels of far greater consistency than kerosene.

The throttling of the engine is done by the piston valve *e*, of which the conically machined end acts as a valve seat, and can cut off entirely the flow of the mixture. Supplementary air flows through z-z_1, while *s* shows a wire gauze net which may be installed in order to prevent carbureter fires on aeroplanes or where there are inflammable materials around. In aeroplane and kerosene engines the vaporizer is provided with two float chambers, in the first in order to set instantly into action the other float chamber should the fuel supply pipe in one break, and in kerosene engines because one float chamber works on the regular fuel, and the other on gasolene or benzene for a start. By a slight adjustment in the opening or closing of the valve *l* the same vaporizer may be made to work with either light or heavy benzene or with benzole. The device is of particular interest because the cheaper grades of fuels may be used in it.

Movable Models for the Explanation of the Airship Engine (*Bewegliche Modelle zur Erklärung des Luftfahrzeugmotors*, -h-. *Deutsche Luftfahrer-Zeitschrift*, vol. 17, no. 22, p. 531, October 29, 1913. 1 p., 5 figs. *d*). The aviator must thoroughly know his engine, so as to be able to detect defects in its working before it actually stops running. As in most cases he cannot handle an engine long enough to become familiar with all the details of its construction, it is believed that a work on a set of properly constructed models might be of advantage; this applies also to the case of large schools where each particular student has only a limited time to devote to the study of the engine. The article describes and illustrates a set of models placed on the market by a German firm, giving a sectional view of the engine, the piston motion, valve motion, etc. All the models are movable, are provided with brief explanatory notes, and appear to be of use for their particular purpose. Two additional models show the operation of the carbureter and of the ignition system, two subjects of particular importance to an aviator.

Machine Shop

Autogenous Welding in Shop Practice on a Large Scale (*Die autogene Schweissung im Grossbetrieb*, J. Knappich. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 47, p. 571, November 21, 1913, 3 pp., 6 figs. *d*). The Augsburg-Nuremberg Machine Company was one of the first German concerns to employ autogenous welding on a large scale; its installations for this purpose have been continually enlarged, and last spring a large special plant was installed, said to be the last word in this branch of engineering. Fig. 3 A and B shows section and plan respectively of the installation. The carbide storeroom located near the machine room *A* is separated from the latter by a fireproof wall with a fireproof door, and has a storing capacity of 10,000 kg. (22,000 lb.). The generation of the acetylene is carried on on the so-called deep generation system, i.e.,

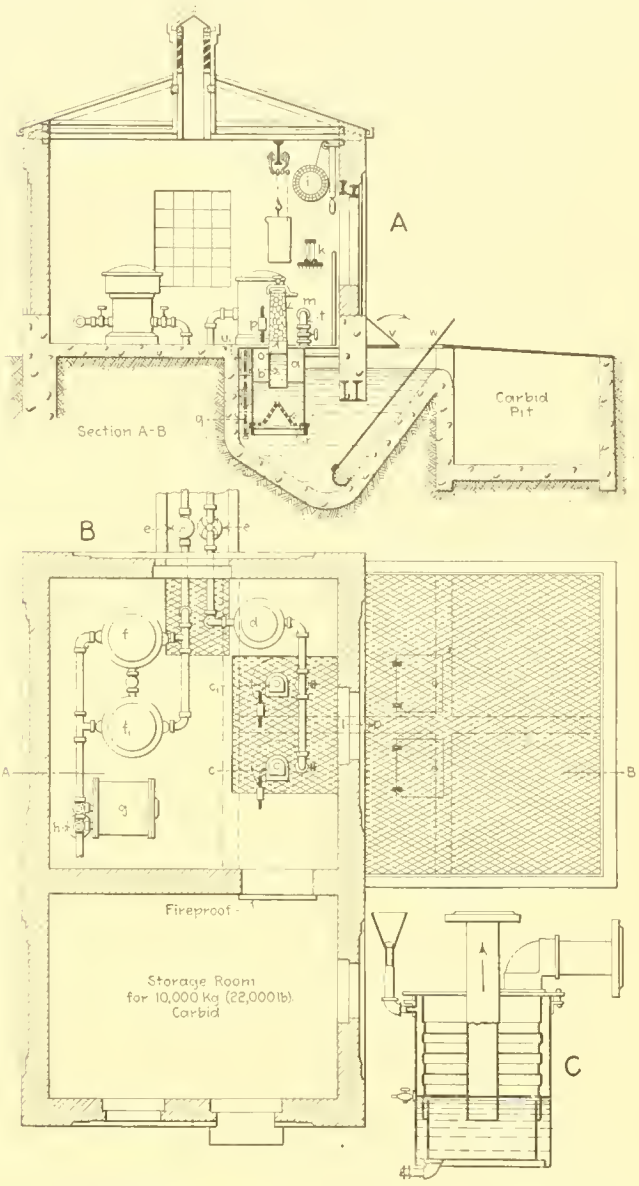


Fig. 3 Acetylene Generating Plant (Autogenous Welding) of the Augsburg-Nuremberg Machine Company

with the generator direct in the water space. This system was adopted because in plants of this size a very important element is that of removing the carbide residues, and for this purpose it is well to have as large a water reservoir as possible, which can be best done with the "deep" system. As shown in Fig. A and B, the machine plant consists of two generators *c* and *c'* for 50 kg.. carbide each, the washer *d* with the water closing device *e*, a gasholder (standing in the open) of 30 cu. m. (1059 cu. ft.) useful volume, cleaners *f* and *f'* of 0.25 cbm. (8.8 cu. ft.) useful volume, station gas meter *g* with a capacity of 31 cbm. (1094.7 cu. ft.) per hour; Knappich central safety water

reservoir *h* (more of it below); gasholder contents indicator *i*, water manometer *k* and emergency lighting *l*.

After being generated in the generators *c* and *c'*, the acetylene flows through the washers *d*, which serve also as water seal, to the gasholder, from which, when required, it flows through the two cleaners *f* and *f'*, gas meter *g* and the Knappich safety water reservoir *h*. By these means the impurities contained in the acetylene and soluble in water, such as ammonia, hydrogen sulphide, etc., are eliminated from it at the same time that it is being generated and stored away; on the other hand, such impurities as hydrogen phosphide, hydrogen silicide, etc., are retained by chemical means in the cleaners *f* and *f'* on the way to consumption (because here the gas flows with less velocity). The acetylene reaches therefore the place of consumption in a state of technical purity, which is very important for the production of good welds.

The generator is always surrounded by a large quantity of water which helps to obtain both an economical gasification of the carbide and a gas free of products of polymerization (owing to the fact that the excess of water provides an effective cooling). Further, since every generator has a capacity of 50 kg. carbide and a production of 15 cbm. (530 cu. ft.) of gas, the amount of air which gets into the charging chamber with the carbide may be considered as negligible, and the formation of explosive mixtures practically eliminated.

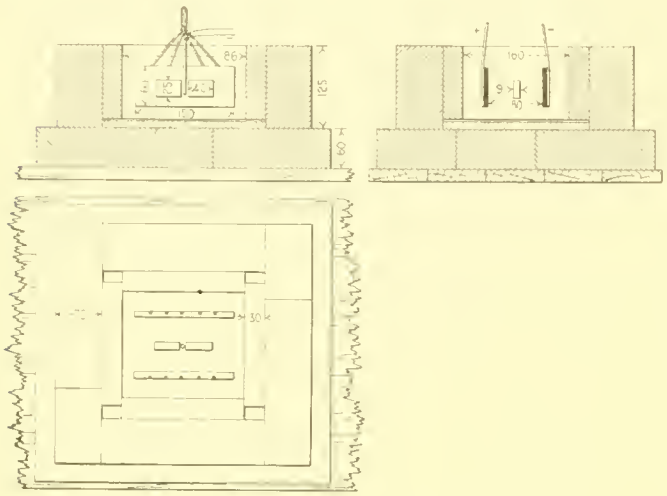


Fig. 4 Apparatus for Electric Case Carbonization

In the cleaners which have to take care of the impurities not readily soluble in water, a product with a chromic acid basis is used (its exact composition is not stated). The cleaners are sealed hermetically by a bell partly submerged in water and provided with an automatic alarm whistle indicating low level of the water seal.

The purpose of the gas meter is to determine the consumption of gas in the plant, as well as the gas output per unit of calcium carbide used. (The latter is especially important in Germany, as under the standard contract of the German Acetylen Society, the carbide factories guarantee a certain output of gas per unit weight of carbide.) In addition to the gas meter, the plant uses a special apparatus (of Dr. Caro) for the determination of gas production from carbide. The water manometer is arranged so that it can be connected with any part of the plant, though as a rule it is on the generator. The emergency lamp (kerosene oil) is provided in case the electric light should fail.

The piping consists of cast-iron pipes, 100 and 80 mm (3.9 and 3.1 in.) in diameter; the cleaners are provided with shunt piping, so as to prevent disturbances in the flow of gas should a cleaner become clogged. By this means the flow of gas may be regulated as desired, and the cleaners connected in parallel.

German government regulations provide that there should be a water seal at each welding stand between the gas piping and the burner to prevent backfiring into the piping when the burner tube becomes clogged, as well as to prevent the oxygen from getting into the acetylene piping. Most of the accidents which have occurred in autogenous welding may be traced back to improperly designed or improperly kept water seals. In large plants, with an extensive system of piping there is the further danger that, with a defective water seal, the back firing may penetrate as far as the apparatus house or gasholder, and make trouble there. To prevent this, the Knappich safety water reservoir has been installed. It is shown in Fig. C, and its characteristic is that it is provided with an alarm whistle which acts automatically: (*a*) when the water level becomes too low; (*b*) when the welding pistol is clogged (the oxygen is then forced to flow through the alarm whistle, and produces the sound of alarm); (*c*) when, through some irregularity in the piping, air is admitted into it. This alarm whistle, which is set into motion by the kinetic energy of the oxygen under pressure, instantly and automatically indicates any error in the actions of the welder or attendants, so that they may be attended to before it is too late. One of the striking facts in connection with this plant (characteristic to a certain extent of acetylene installations generally) is the small attendance required. The present plant having an output of 300 to 600 cbm (10,594 to 21,188 cu. ft.) per day, or about five times as much as would be required for the lighting of a city of 5000 inhabitants, *has only one man for its attendance*. More than 50 welding burners are operated throughout the plants, from the smallest to the largest size, autogenous welding being used for the most varied purposes.

Electrical Case Carbonization of Iron and the Properties of the Product Obtained (*Electricheskaya tcementatciya jeleza i svoistva poloochenava prodookta*, I. A. Feshchenko-Chopovski. *Journal of the Russian Metallurgical Society* (in Russian), no. 3, 1913. p. 245, 10 pp., 3 figs. *de*). Garnier observed as early as 1883 that an electric current increases the velocity of the cementation process when the iron serves as a cathode, and retards it when the iron serves as an anode. In 1909, Prof. P. V. Ijevski, while investigating, in Russia, case carbonization of iron by means of illuminating gas, passed an electric current of low potential (about 15 volts) and large amperage (300 amperes) through the iron rod under test, in order to bring it up to the temperature required for case carbonization; the rod was in a glass tube, through which the gas flowed continuously at a given velocity. Data of these tests have never been published. The present author applied practically the same principle, but in a radically different form, which permitted him to effect the carbonization by means of a solid powder. In his first tests he used a so-called cryptol rheostat with a few pieces of soft iron placed in the cryptol mass.

The current meets a very large resistance while passing through the cryptol carbon, and in accordance with the Joule law, produces a large evolution of heat. In the author's tests a current of 5 to 8 amperes was passed at 250 volts during two to three hours, the iron pieces attaining their full temperature in less than half an hour. These tests have not given fully satisfactory results, due probably to faulty construction of the experimental furnace, and another type of furnace was worked out, in which the comparatively expensive cryptol was replaced by a mixture of retort coal and charcoal, with an addition of 40 per cent of barium carbonate (in some of the tests cryptol seems to have been used, however). The experimental furnace used is shown in Fig. 4, all the dimensions being given in millimeters (1 in. = 25.400 mm). A few bricks were laid flat on a wooden board, thus forming the bottom of the furnace, which was further covered by sand and protected by a sheet of asbestos. A few more bricks formed the walls of the furnace, leaving in the middle a rectangular space 7.4 in. by 6.4 in., 5 in. deep. As electrodes, iron bars, 6 in. by 2.4 in. by 0.33 in., were used, connected to copper wires as shown in the figure. Direct current of 250 volts was stepped down to 5 volts; the carbonized test pieces, iron bars 1.6 in. by 1 in. by 0.3 in., were placed in the space between the electrodes, two test pieces being generally used at a time, while as much as eight have been successfully handled at once, this being the maximum for a furnace of given dimensions. The distance between the electrodes was 3.2 in.

The carbonization proved to be even, and as deep as desired. Tests were made to determine the depth of the carbonized layer as a function of time and of temperature, and it was found (the original article contains full tables of tests) that, with a powder consisting of 60 per cent mixture of retort carbon and charcoal, and 40 per cent barium carbonate, and temperature of 970 deg. cent. (1778 deg. fahr.), the speed of cementation was 0.60 mm (0.0236 in. per hour). The functional relation between the temperature of the carbonization process and the speed of diffusion of carbon through the iron could not be established fully, and appears to follow some complex law. It has, however, been found to increase, as the temperature rose from 900 to 1000 deg. cent. (1652 to 1832 deg. fahr.). It has also been found that close packing of the powder near the test piece improved the results obtained, and also that the side of the piece towards the entering current was carbonized somewhat deeper than the opposite side, but this difference was slightly noticeable at high temperature and for long tests. Tests of hardness by the Brinell method have shown that the surface hardness increases with the thickness of the layer of case carbonization.

Materials of Construction

The Melting and Vaporization of Refractory Oxides (*Das Schmelzen und Verdampfen hochfeuerfester Oxyde*, wbo. *Tonindustrie-Zeitung*, vol. 37, no. 128, p. 1693, October 30, 1913. 1 p. *e*). The article contains data of tests on the melting point of refractory oxides by C. W. Canolt at the U. S. Bureau of Standards and Otto Ruff at the Technical High School, Danzig, Germany. Only the latter will be here reported. Oxides of the following elements were investigated: beryllium, magnesium, calcium, aluminum, yttrium, chromium and lanthanum, as well as zirconium dioxide, tin dioxide, titanium dioxide, cerium dioxide, thorium dioxide, niobium pentoxide, and tantalum pentoxide. It was found that only aluminum oxide had a melting point independent of the influence of the reducing action of the furnace atmosphere; beryllium oxide has been found to be nearly independent, but the relation of its reducibility to pressure and composition of the furnace atmosphere has not yet been definitely established; in the case of zirconium dioxide its composition before melting still needs investigation. For refractory containers beryllium and zirconium oxides appear to be the most suitable; aluminum oxide has too low a melting point for certain application, while magnesium oxide is good only where means have been taken to prevent its too rapid vaporization. The other oxides are easily reduced to carbides in the furnace atmosphere. The article contains a complete table of melting points of the oxides investigated, of which the following may be mentioned here (in nitrogen, first figure at atmospheric pressure, the other in partial vacuum, 10 to 30 mm.): beryllium oxide, BeO: 2200 and 2525 deg. cent. (3992 and 4577 deg. fahr.); magnesium oxide, MgO: 2500 and 2550 deg. cent. (4532 and 4622 deg. fahr.); aluminum oxide, AlO: 2010 and 2010 deg. cent. (3650 deg. fahr.).

Refrigeration

Increasing the Output of Cold of Carbon Dioxide Refrigerating Machines Particularly with High Condenser Pressures (*Beitrag zur Erhöhung der Kälteleistung und der Leistungsziffer von Kohlensäurekältemaschinen insbesondere bei hohen Kondensatordrücken*, R. Plank. *Zeits. für die gesamte Kälte-Industrie*, vol. 20, no. 10, p. 189, October 1913. 7 pp., 6 figs. *dtA*). Discussion of the thermodynamic principles of operation of compression refrigerating machines, and description of an improvement devised by the author, of particular importance for localities where cold cooling water is not easily available. The useful output of cold depends mainly, apart from the amount of heat of evaporation, on the state of the cold carrying medium in front of the regulating valve. The amount of moisture in the steam at entering the evaporator, and the output of cold secured are inversely proportional to the heat contents of the cold carrying medium in front of the regulating valve, and many efforts have been made to keep the latter as low as possible, e.g., by inserting liquid coolers working on the counter current principle, and securing a reduction of the cold carrying medium to nearly the temperature of the cooling water: for CO_2, especially in the neighborhood of the critical point, the gain thus obtained is quite substantial.

The heat content i is in general a function of temperature and pressure, but while the relation between heat content and temperature is simple, this is not so with pressure, where the relation is expressed by the following somewhat complicated differential equation:

$$\left(\frac{\partial i}{\partial p}\right)_t = -AT\left(\frac{\partial v}{\partial t}\right)_p + Au = AvT\left(\frac{1}{T} - \alpha\right)$$

where t or T denotes temperature, p pressure, v volume, $A = \frac{1}{427}$, mechanical heat equivalent, and $\alpha = \frac{1}{u}\left(\frac{\partial v}{\partial t}\right)_p$, thermal coefficient of expansion referred to the volume v. There may be several relations between α and $\frac{1}{T}$, the former being equal, smaller or larger than the latter; further α may be equal to zero or infinity.

For cold carrying media with a low lying critical temperature the state in front of the regulating valve is characterized by the relation $\alpha > \frac{1}{T}$ which applies both to the case of real gases and still more to liquids and vapors in the neighborhood of the critical point. When $\alpha = \frac{1}{T}\left(\frac{\partial i}{\partial p}\right)_t$ is negative, and therefore a rise in pressure reduces the heat contents. An increase in the output of cold may therefore be obtained simply by submitting the cold carrying medium, after its exit from the condenser, to a second isothermal compression; if this supplementary compression is adiabatic, the heat of compression must be removed in an additional small cooler, and in any case a gain in cold output is obtained, this gain being in most cases bought very cheaply since the work required for the

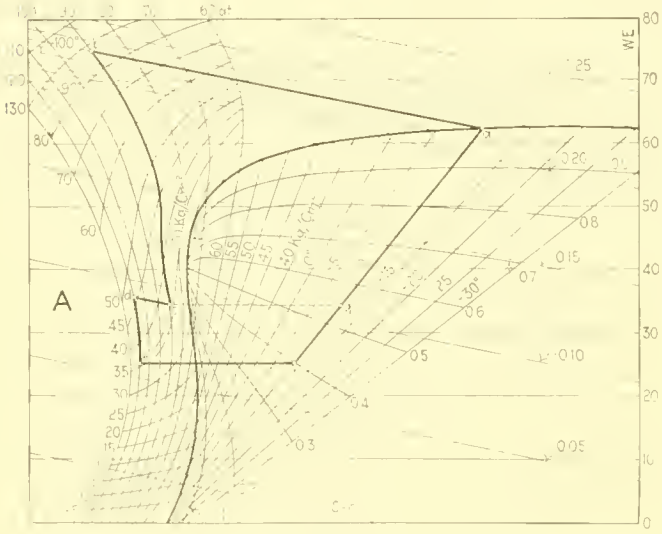


Fig. 5A JS Diagram, CO_2 Refrigerating Machine

compression of the CO_2 coming out of the condenser is very small, owing to the small volume of the gas so treated. The ratio of the cold output gained Q_0' to the compression work AL', or the efficiency $\epsilon' = \frac{Q_0'}{AL'}$ of the supplementary process, is, especially with high temperatures of the gas coming from the condenser, sometimes as much as four times higher than the efficiency of the original process $\epsilon = \frac{Q_0}{AL}$, and therefore, by the application of supplementary compression, not only the general, but also the specific output of cold is raised (a table in the original shows that this gain may be as high as 85 per cent, and has in several cases proved to be around 40 per cent).

For the practical application of the new process in the first instance is required a small pump that would compress the CO_2 to about 120-150 atmospheres. The compresison is practically adiabatic and the temperature of the gas rises therefore somewhat. 10 to 15 deg. cent. (18 to 27 deg. fahr.); this rise must be taken care of, which is done in a small cooler, in the form of a double wall pipe working on the counter-current principle. While by means of slow compression and efficient jacket cooling practically isothermic compression may be obtained, it is more practical to employ the above described combination of adiabatic compression and subsequent cooling.

To attain the greatest economy of the process, it is essential that the cold carrying medium be as thoroughly cooled

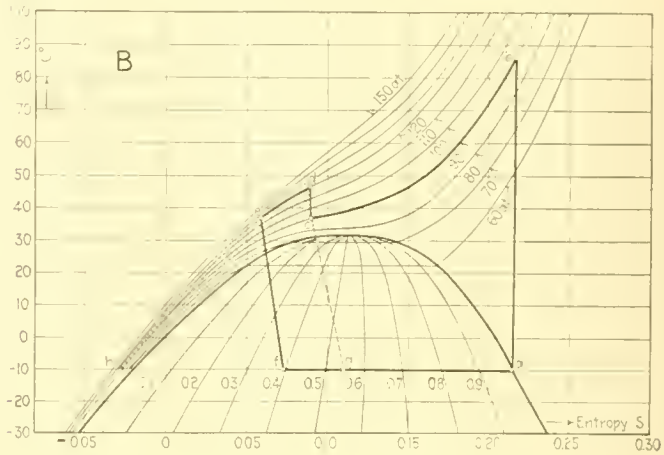


Fig. 5B TS Diagram, CO_2 Refrigerating Machine

as possible both before and after the supplementary compression. The power consumption for the supplementary compression is the smaller, the lower the temperature of the gas under compression. Under normal conditions the volume of the compression pump is 1/6 to 1/7 of that of the main compressor.

To illustrate the above description, both the usual and the modified processes are reproduced in the *JS*, *TS*, and *JP* diagrams in Fig. 5 A, B, C. The *JS* and *JP* diagrams are

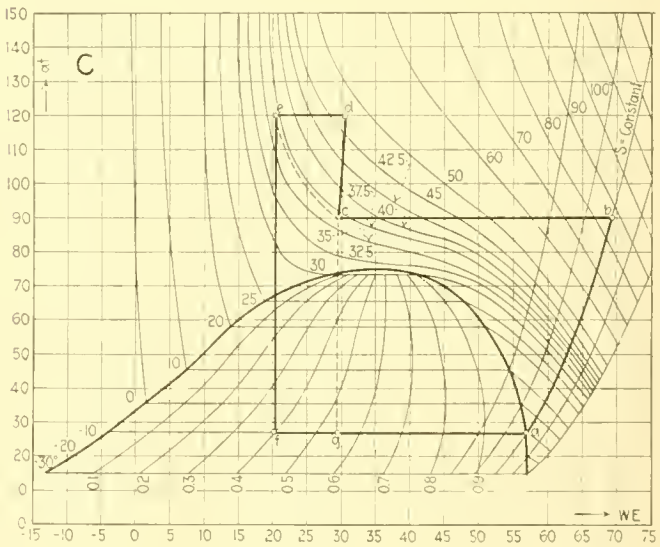


Fig. 5C JP Diagram, CO_2 Refrigerating Machine

particularly suitable for estimating the gain obtained, since these diagrams show both the power consumption of adiabatic compression in both cylinders and the power output, while *D* shows the gain in specific cold output when the new process is used. The usual process in refrigerating machines of this type occurs along the line *abcg* (Fig. 5 A), where *ab* represents the adiabatic compression of the gases coming out of the evaporator, *bc* the isobar in the condenser, *cg* the throttling curve in the regulating valve, and *ga* the isobar in the evaporator. The vertical distance between the points

g and a shows the available output of cold, while ab magnified five times represents the equivalent of the compressor work. The *modified process* follows the line $abcdefg$ where cd, to the same scale as ab, shows the equivalent of the work of adiabatic compression of the pump, while de is the isobar of the supplementary cooler, and ef the displaced throttling curve. The vertical distance between the points f and g represents the gain in cold production (the points c and e are on the same isothermal).

In Fig. B both processes are plotted on the TS diagram. The area $abckga$ is equivalent to the work of compression in the usual system, and ga may be considered as the measure of the cold output. For the new system the equivalent of the compression pump work is the area $cdehkc$, so that the total work of compression is given by the area of $abcdehkfa$, while the gain in cold output is characterized by fg. On the JP diagram the new process is shown in Fig. C: the horizontal distance between the points a and b is equivalent to the compressor work, and the horizontal distance between c and d to the work of supplementary compression

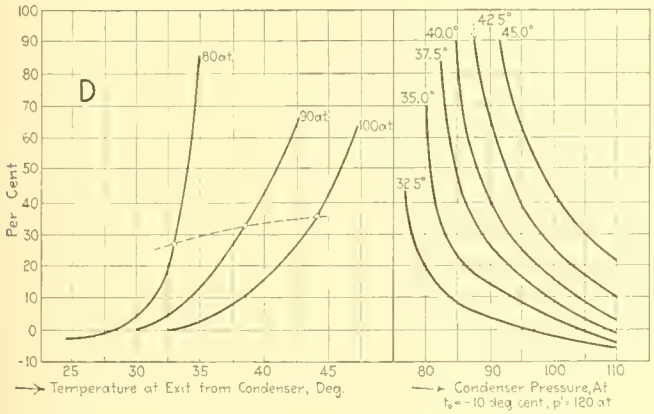


Fig. 5D Theoretical Cold Output, in Calories per Kg. of CO_2, at −10 Deg. Evaporation Temperature (a, Old System; n, New System)

(pump). The isobars bc, de and fga appear as straight horizontal lines, but the adiabatic curves ab and cd have lost the regularity which characterized them in Fig. A and B. The throttling processes in the regulating valve are represented by the vertical straight lines ef and cg, while the output of cold is shown in the old system by ga, and in the new by fa.

To determine the practical gain in the production of cold with the new system, all that is necessary is to know the temperature of CO_2 at coming out from the condenser when high condenser pressures are used. The gain may then be readily determined by means of Fig. 5 D and E. As has been shown by tests on actual machines, there is the following relation between condenser pressure and exit temperature: $p = 80$ atmospheres, $t = 33$ deg. cent. (91.4 deg. fahr); $p = 90$ atmospheres, $t = 38.5$ deg. cent. (101.3 deg. fahr.); $p = 100$ atmospheres, $t = 44$ deg. cent. (111.2 deg. fahr.). In Fig. D and E these temperatures are indicated by small circles and connected by a dotted line. Table 1 shows the respective gains for a temperature of evaporation of —10 deg. cent. (14 deg. fahr.), and a pressure in the auxiliary pump of $p' = 120$ atmospheres. These gains are still larger with higher pressures p', but could not be exactly computed on account of defects in the experimental plant. The volume of the small auxiliary pump is to the volume of the main compressor in exactly the same ratio as the specific volume v of the CO_2 at pressure p and temperature t is to the specific volume v_0'' of dry saturated steam at the evaporation temperature t_0. With $t_0 = -10$ deg. cent., $p = 90$ atmospheres, $t = 38.5$ deg. cent., v'' is 14.24 liters per kg. and v is 2.08 liters per kg. Therefore

$$\frac{v'}{v_0''}\ 100 = 15 \text{ per cent,}$$

which means that the volume of the auxiliary pump is about 15 per cent of that of the main compressor, both being assumed to be single acting. The author applied for a German patent for his invention.

TABLE 1 IMPROVEMENT IN COLD PRODUCTION WITH THE PLANK DEVICE

Condenser Pressure	Temperature of CO_2 at Exit from Condenser, Deg. Cent.	Gain in Output of Cold, Per Cent	Gain in Specific Output of Cold, Per Cent.
80	33	48	28
90	38.5	46	32
100	44	44	35

Steam Engineering

Blowing-off Boiler Deposits (*Abblasen des Kesselschlamms, Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 46, p. 567, November 14, 1913. 12 pp., 2 figs. *dp*). The article states that the usual practice of letting the blow-off valve open for several minutes entails nothing but a useless waste of heat and water from the boiler. Merely a cone-shaped vortex is formed in the boiler deposit around the blow-off cock, and only the mud in that vortex is re-

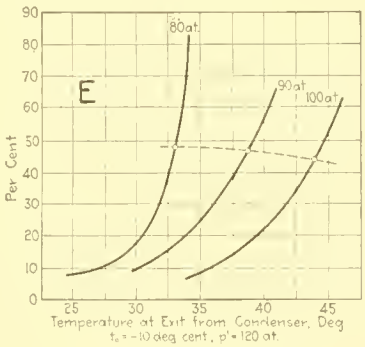


Fig. 5E Gain in Output of Cold

moved. To do that requires not more than 3 to 5 seconds, while for the rest of the time that the cock is opened, it is clear water that flows through, and it takes about 2 hours for the space in the neighborhood of the blow-off valve to fill in again. The best practice is therefore to open the blow-off valve every 2 or 3 hours for a few seconds. If the usual hand wheel blow-off valve is used, however, it would be hardly advisable to let the boiler attendant blow off the boiler so often and for such a short time, and the *Gestra valve* (Fig. 6) has therefore been arranged in such a manner that the fireman can from his stand operate it by a chain or foot treadle (Fig. A). It is provided with two stop cones (Fig. B). The main cone a with its seat may be re-

moved for repair purposes; the safety cone *b* will still remain automatically closed; the double closing arrangement is also effective in preventing possible leaks.

Increasing Firetube Boilers (*Vergrösserung von Flammrohrkesseln*, Pradel. *Braunkohle*, vol. 12, no. 32, p. 547, November 7, 1913. 3 pp., 4 figs. *d*). It is often desirable to increase the output of a fire-tube boiler without either increasing the space occupied by the boiler, or going to great expense. This can be done by the so-called Eimert battery manufactured by a German concern, and consisting

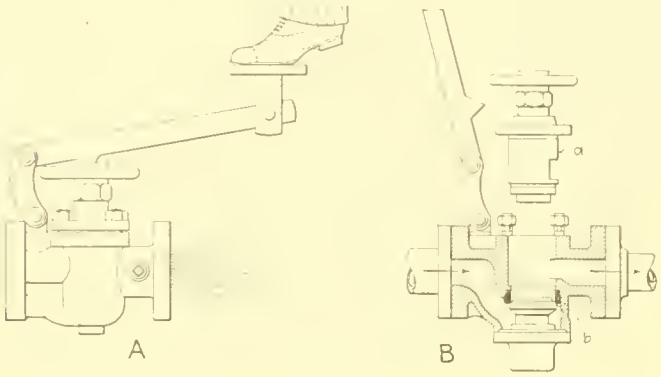


Fig. 6 Gestra Valve for Blowing-Off Boiler Deposits

of seamless Mannesmann pipes of special steel stayed, by seamless welding, in a header of appropriate shape and size. In Fig. 7 is shown such an Eimert battery constructed in a side flue of a boiler. This arrangement provides the fire-tube boiler with all the advantages of a water-tube boiler in respect to the speed with which steam can be raised. The action of the battery of tubes is based essentially on the fact that the hot gases are forced to play around the tubes all along their length, and, by a proper distribution of joints, an extremely rapid and vivid circulation of water is secured, such as is generally lacking in a fire-tube boiler. The battery, which is inserted into the flue on rollers in such a manner that it slopes forward, is connected to the lowest part of the water space in front, and to the highest in the rear; further, the rear steam collector is connected directly with the steam space in the main boiler. Tests have shown that with this arrangement an increase in steam generation as high as 40 per cent has been actually obtained. The article gives data of tests with and without the Eimert battery, and shows that the efficiency of the plant before the additional installation was 50.52 per cent, and became 75.30 after the Eimert battery was installed; water evaporated per hour rose from 2050 kg. (4510 lb.) to 2300 kg. (5060 lb.), the rate of evaporation having changed from 25.59 to 28.71 kg. per qm-hr. (from 5.27 to 5.91 lb. per sq. ft-hr). The losses in both cases are given as follows: smokestack: before the installation of the battery 20.45 per cent, after —11.95 per cent; radiations, residues, etc.: before —29.03 per cent, after —12.75 per cent.

Friction of Gases against the Walls of Brick Passages. (*Trenye gazof o stenki kirpichnikh kanalof*, V. A. Mojaroff. *Journal of the Russian Metallurgical Society*, no. 3, 1913, p. 335, 35 pp., 2 figs. *mpA*). The author, in connection with some repairs to a blast furnace installation, had to determine how much hotter a blast a Massick and Crookes stove will give than a similar Cowper stove, all other conditions being equal. To do this, the author had, among other things, to determine the friction of gases against the walls of brick passages, a problem with which the builder of smokestacks, brick arches, etc., has also often to occupy himself. Guided by Professor Grum-Grzimailo's theory of the application of methods of hydraulics to the calculation of metallurgical furnaces, the author derived a general formula for the resistance to the flow of gases through brick-lined passages, and determined the coefficient of friction of the gases for this case.

With the same area of cross-section, the passages through which a gas flows may have very different shapes, from that of a circle to a long narrow slot; hence, the ratio of perimeter of passage to its cross-section may be variable. Since the friction of a gas against the walls of a passage is proportional to its perimeter, the amount of work spent to overcome this friction, is not equal in the case of several passages with equal cross-sections, but unequal perimeters: the ratios of loss of head due to friction in such passages is proportional to the ratios of their perimeters. Since of all sections of equal areas, the circle has the minimum perimeter, the perimeter of a circle and the work of forcing the gas through a passage of circular cross-section may be taken as units; then for all other sections of equal areas their perimeters and loss of head due to friction may be expressed as $\frac{S}{C_1}$ or as $\frac{S}{\pi D_1}$ where S is the actual perimeter of a section of the gas passage, C_1 the circumference of a circle of area equal to that of the actual cross-section of the passage, and D_1 the diameter of this circle.

The circumference of a circle is proportional to its diameter, the area to D^2; the friction loss in the case of a circular passage is proportional to the circumference of the passage; the volume of the gas passing in unit time to the area, and since the energy of the gas is a function of its quantity, it is evident that that part of its energy which is lost to overcome the friction against the walls of the passage, and the

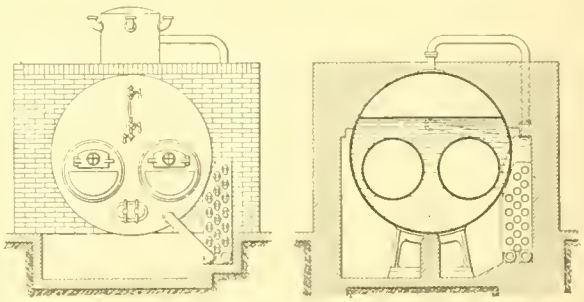


Fig. 7 Firetube Boiler with Eimert Battery

corresponding loss of head, will vary as the ratio of the diameter to the area of the passage, all other conditions being the same, or as $\frac{4}{D_1}$. In other words, in the case of the flow of gas through circular passages, the loss of energy due to friction is inversely proportional to the diameter of the passage. By combining this formula with the one preceding, it is seen that, whatsoever the shape and free area of cross-section of the passage may be, the loss of en-

ergy in the gas due to friction is proportional to the expression

$$\frac{S}{\pi D_1} \cdot \frac{4}{D_1} = \frac{S}{\frac{\pi D_1}{4}} = \frac{S}{\omega}$$

where ω is the area of the free section of the passage. For a given length of flow of gas L the loss of energy is also proportional to L.

The work of friction of gas against the walls of the passage and the corresponding loss of head vary with the amount of gas flowing, and are therefore a function of the average velocity of flow of gas through the passage, and since the pressure of the gas varies also with the change of temperature, the friction loss must be a function of the pressure or density of the gas, or, combining the two, $f(v_t, p_t)$. The exact expression of this function is unknown.

In hydraulics it is usually assumed that frictional resistance is a linear function of the velocity of flow, and, in the absence of proofs to the contrary, the same may be done in the case of flow of gas. The coefficient which should be added to the expression $\frac{SL}{\omega} v_t p_t$ depends on the physical properties of the walls of gas passages, and, in the case under investigation, may be called the coefficient of friction of a gas against brick walls; it will be denoted here by the letter m. Summing up, the loss of head due to friction, expressed in millimeters of water, and denoted by γ, may be expressed as

$$\gamma = m \frac{SL}{\omega} v_t P_t$$

where m is the coefficient of friction of gas against brick walls; S perimeter of the passage in meters; ω area of section of the passage in square meters; L length of the passage through which the flow is measured, in meters; v_t velocity of flow of gas in the passage in meters, at t deg. cent.; p_t weight of 1 cu. m. of gas in kilograms, at an average temperature of t deg. cent. which the gas has in the investigated part of the passage.

The same formula may be expressed as $\gamma = m \frac{SL}{\omega^2} Q_o p_o$, where Q_o is the volume of the gas flowing through the passage per second, and p_o the weight of 1 cu. m. of gas at 0 deg. cent. and 760 mm. pressure.

The constant m which is a function of the physical properties of the brick clad surface of the passage is the one that must in all cases be determined in order to make possible the calculation of the energy loss due to friction, and the author shows that m is the head in millimeters of water corresponding to the loss of energy due to friction, in 1 second, of air at 0 deg. fahr. and 760 mm. pressure, moving with a velocity of 1m/sec. (3.28 ft. per sec.) through a brick lined passage the area of the cross-section of which satisfies the equation: $\frac{\omega}{S} = 1.293$. If the passage is circular, $\frac{\omega}{S} = \frac{D}{4} = 1.293$, and hence $D = 5.172$ m. $= 16.967$ ft. In the case which was specially investigated by the author, m was found to be equal to 0.016, all the other units being metric, as stated above, and it appears that this coefficient may be used for general purposes of practical calculations (it was determined both experimentally, and by calculation).

Concerning the Bone-Schnabel Boilers (*Zur Beurteilung der Bone-Schnabel-Kessel*, G. Neumann. *Stahl und Eisen*, vol. 33, no. 47, p. 1929, November 20, 1913. 7 pp., 2 figs. *et*). The author accepts neither the theory of explosive waves of Jüptner, nor Bone's theory of catalyzing surfaces, nor the electrone theory of Carleton Ellis. The actual combustion in the tube ceases 20 cm (7.8 in.) from the front opening, the rest of the tube serving simply as a heating space; in the preheater there is likewise no actual combustion, but heat transference only. At the same time it has been proved experimentally that it does not pay to have the tube filled only as far as actual combustion occurs. This fact, as well as the further fact that the distribution of heat in the surface combustion boiler is very like that in an ordinary boiler, make all of the above theories untenable, according to the author's opinion. As compared with other boilers, the Bone-Schnabel has the following particulars: (*a*) the presence of intentionally placed resistances in the path of the gas stream against which the gas must constantly impinge; (*b*) introduction into the stream of the gases of combustion of a second indirectly acting heating surface, namely, of the heat radiating surface of the pieces of porous material lying on the outside; (*c*) increase in the velocity of the flow of gases through decrease of the free section of the tube, caused by the introduction of the porous bodies. As the most important property of these boilers may be named their high heat absorption per unit of heating area, as well as the high specific output combined with a low temperature of flue gases; attention may also be called to the completeness of combustion in the new type of boilers.

As regards filling the heating tubes in the zone of combustion with porous granules, it certainly has in many cases a beneficial effect on the completeness of combustion. Most fuels, solid as well as liquid and gaseous, either contain initially or develop in the gasification preceding the combustion, a number of heavy hydrocarbons which in ordinary systems of firing leads to incomplete combustion through formation of soot; in order that these hydrocarbons be fully burned, the temperature of the combustion must be so high as to cause their decomposition, a condition which is but seldom satisfied in the usual practice, but actually followed out in the Bone-Schnabel boiler. Owing to the fact that the heating tubes are filled with porous granules of a material poorly conducting heat, these tubes contain numerous hollow spaces protected, by the poor heat conductivity of the material, from radiation losses to the tube walls, and thereby permit the gases to burn at a high temperature, in thorough mixture with air, and therefore without soot formation. In addition to this, the thorough mixture of gas and air previous to the entrance of the combustible material into the combustion chamber very materially raises the velocity of combustion as well as its temperature, especially when the excess of air is as low as appears to have been used in the tests described. Further, since the hollow spaces in the porous elements in the tubes do not form consecutively connected in one direction passages, the gases are compelled to impinge from time to time against the granules and to produce thereby violent eddy motion, which, in its turn, forces the particles of the mixture which have reached the zone of combustion first, to deflect towards the colder walls of the tube, and to drive inside, into the zone of combustion, the outer cold particles of gas. There occurs therefore,

first, a thorough and uniform combustion of the entire gas mass, and, second, a constant giving-up of heat from the gas particles to the tube walls. As regards the porosity of the granules, the author, in the case of the Bone-Schnabel boiler firing, does not attach to it much importance. The mixing of the air and gas may very well take place between the granules themselves, and not in their pores, which, if they were there initially, would soon be clogged up when certain kinds of gases are used (e.g., blast-furnace gas).

According to published data, the specific evaporation of the Bone-Schnabel boiler is exceptionally high, being 80 to 150 kg/qm (16.4 to 30.75 lb. per sq. ft.) as compared with the rate of evaporation of 40 kg/qm (8.2 lb. per sq. ft.) of the high duty boiler with ordinary firing (it must be, however, borne in mind that the Bone-Schnabel boiler delivers only saturated steam, while the rate of evaporation for the high duty modern boiler refers to superheated steam). In addition to the high rate of evaporation, the Bone-Schnabel boiler is peculiar for the low temperature of its exhaust gases.

Now, since it has been found that the evaporation in the Bone-Schnabel boiler is distributed in approximately the same way as in the ordinary boiler, it appears that all the parts of the heating surface, and not the zone of combustion alone, contribute equally to the larger heat transference, and it becomes of interest to establish the causes that permit the Bone-Schnabel boiler to generate twice to thrice as much steam as the usual high duty modern boiler. In the first place it must be remembered in this connection that in addition to the direct heating surface of the heating tube there is also an indirectly acting heating surface formed by the faces of the granules directed towards the walls of the heating tubes. The granules lying in the inner parts of the tube and protected from radiation losses, must have the temperature of the gases of combustion, while the faces of the granules directed towards the tube walls will have a temperature between that of the gases of combustion and that of the walls, the temperature of the latter granules being so high that the heat transferred to the indirect heating surface from the gases of combustion should be equal to that radiated from the granules to the tube walls. While the temperature of the granules forming the indirect heating surface, and the dimensions of the latter referred to the direct heating surface, cannot yet, through lack of sufficient data, be determined analytically, the author assumes that the value of the indirect heating surface is equal to one-half of that of the direct heating surface of equal area, and expresses therefore the total heating surface as

$$H_g = 1.5H_d$$

where H_d is the direct heating surface (the heating surface of the tubes).

Of still higher significance is, however, the fact that, owing to the contraction of the free section of the tubes as compared with that in ordinary types of boilers, the velocity of flow of the gases of combustion is many times higher. Nusselt and others have shown long ago that for an equal head of temperature between the heating surface and the gases of combustion, the heat transmission per unit of time and area is proportional to the velocity of the flow of gas. Thus Nusselt has shown that when the velocity of the flow of gas has been increased from 11.89 m/sec. to 27.2 m/sec., the heat transmission, per sq.m. of surface hour and deg. cent. of temperature difference, rose from 46.9 to 91.7 WE (185.7 to 363.1 B.t.u.), or about doubled. While these figures, which were derived for comparatively low temperatures, cannot be without further tests applied to the case of the far higher temperatures with which we have to deal in this case, it must be also borne in mind that the velocity of gases in the Bone-Schnabel boiler tubes is considerably in excess of 27.2 m/sec. (89.2 ft. per sec.). Besides, the temperature of combustion, and therefore also the average difference in temperature between the heating tubes and the gases of combustion is much higher in the type of boiler under consideration than in the usual boilers, and this again materially affects the rate of evaporation. Recapitulating all the above, one may assume that the higher gas velocity and difference in temperature at least doubles the heat transference to the heating surface, and since the heating surface itself, through the addition of the indirect heating surface, is one and a half times as large as in the ordinary boiler, the output of the Bone-Schnabel boiler, as compared with the ordinary type, must be $1.5 \times 2 = 3$ times as large, and the above considerations explain not only the higher output of the boiler, but also the lower temperature of its flue gases.

A Suggested Improvement in the Construction of the Surface Combustion Boiler. The great objection to the Bone-Schnabel boiler lies in the large amount of power consumed by the draft fan, and the author raises the question as to whether filling the tube with porous granules is really the best way to raise the efficiency of the boiler. In his opinion, in the Bone-Schnabel boiler not enough attention is paid to the distinction between what the zone of combustion and the heating zone proper have to do. The author has found that, in order to increase the specific heat absorption, it is of advantage to use high velocities of the flow of gas, as well as to build-in another indirectly acting heating surface which would take up by contact the heat from the gases acting on the direct heating surface, and transfer it, by radiation, to the tube walls. This part of the problem is only imperfectly solved in the Bone-Schnabel boiler, since, in addition to conditions which require an excessive amount of power at the draft fans, a large amount of the heating material is cut off from the tube walls by poor heat conductors, and thus prevented from participating in the transference of heat. Further, even while through the above described eddy action, most of the gases do reach, at one time or another, the heating surface of the tubes, the fact that the contact between the gas and the heating tubes is not continuous, is not of advantage, and the boiler would have shown a much lower efficiency if it were not for the fact that the velocity of the gas along the tube surface is greater than in the other parts of the tube, and that therefore a larger part of the gas flows in direct contact with the tube wall. Instead, therefore, of shaping the tube as shown in Fig. 8 A, which is the Bone-Schnabel construction, the author recommends the design shown in Fig. B, with solid elements placed in the tube; by this means the free section is reduced, the velocity of the gases of combustion considerably increased and a second heating surface created, acting indirectly, by radiation. With this kind of tubes the partial vacuum required at the boiler end is only a small part of that necessary with the Bone-Schnabel tubes (which means a saving in power at the fan), while the cleaning of the tubes is made much easier, a fact of importance especially when working with blast furnace gases.

TABLE 2 BONE-SCHNABEL BOILER WITH COKE-OVEN GAS FIRING

		Per Cent		
Coke oven gas, heating value, 3597 WE per cbm. = 403 B.t.u. per cu. ft.	CO_2	0.025	0.025 cbm. CO_2	0.390 cbm. CO_2
	CO	0.065	0.065 cbm. CO_2	1.040 cbm. H_2O
	CH_4	0.260	0.260 cbm. CO_2 0.520 cbm. H_2O	4.373 cbm. N_2+O_2
	C_2H_4	0.020	0.040 cbm. H_2O 0.040 cbm. CO_2	5.803 cbm. (1.61 cbm. of flue gases per 1000 WE = 14.5 cu. ft. of flue gases per 1000 B.t.u.)
	H_2	0.480	0.480 cbm. H_2O	
	O_2	0.037	0.037 cbm. O_2	
	N_2	0.113	0.113 cbm. N_2	
			0.213 cbm. O_2	
		100	4.010 cbm. N_2	

CO_2 $0.390 \times 0.395 = 0.154$
H_2O $1.040 \times 0.343 = 0.357$
N_2+O_2 $4.373 \times 0.284 = 1.242$

Heat content of flue gases $= 1.753 \times 80 =$ 140 WE $= \frac{140}{3597} = 3.9$ per cent

Flue gas losses	3.9 per cent
Radiation and conduction	2.5 per cent
"Gross" efficiency	93.6 per cent
	100 per cent

"Gross" efficiency	93.6 per cent
Gas loss to driving the fan	5.2 per cent
"Thermo-technical" efficiency	88.4 per cent

Boiler output 3000 kg. (6600 lb.) of steam at 100 deg. cent. from water at 0 deg. cent.

Steam generation per cbm. of gas $= \frac{3597 \times 0.936}{637} = 5.29$ kg. (= 0.329 lb. of steam per 1 cu. ft. of gas).

Gas consumption per hour $= \frac{3000}{5.29} = 567$ cbm. = 20,015.1 cu. ft.

Flue gases per hour $= 567 \times 5.8 = 3290$ cbm. = 116,140 cu. ft.

Flue gases per second $= \frac{3290}{3600} = 0.91$ cbm. (15 deg. cent) = 32.3 cu. ft. (59 deg. fahr.).

Fan power consumption $= \frac{1.17 \times 550 \times 10{,}000}{75 \times 0.5 \times 9450} = 18.2$ h.p.

Steam consumption at the fan $= 18.2 \times 9 = 164$ kg./hr. = 360 lb./hr. $= \frac{164}{3000} = 5.5$ per cent.

Corresponding gas loss for the fan $= 5.5 \times 0.936 = 5.2$ per cent.

TABLE 3 BONE-SCHNABEL BOILER WITH BLAST FURNACE GAS FIRING

		Per Cent		
1 cbm. blast-furnace gas, heating value 861 WE (96.4 B.t.u. per cu. ft.)	CO_2	0.114	0.114 cbm. CO_2	0.388 CO_2
	CO	0.274	0.274 cbm. CO_2	0.040 H_2O
	H_2	0.040	0.040 cbm. H_2O	1.348 N_2+O_2
	N_2	0.572	0.572 cbm. N_2	1.776 cbm. (2.06 cbm. of flue gases per 1000 WE = 18 cu. ft. per 1000 B.t.u.).
			0.737 cbm. N_2	
		100	0.039 cbm. O_2	

CO_2 $0.388 \times 0.395 = 0.153$
H_2O $0.040 \times 0.343 = 0.013$
N_2+O_2 $1.348 \times 0.284 = 0.382$

Heat content of flue gases $= 0.548 \times 80 =$ 44 WE $= \frac{44}{861} = 5.1$ per cent

Flue gas losses	5.1 per cent
Radiation and conduction losses	−2.5 per cent
"Gross" efficiency	92.4 per cent

"Gross" efficiency	92.4 per cent
Gas loss to driving the fan	7.1 per cent
"Thermo-technical" efficiency	85.3 per cent

Boiler output 3000 kg. (6600 lb.) of steam at 100 deg. cent. from water at 0 deg. cent.

Steam generation per cbm. of gas $= \frac{861 \times 0.924}{637} = 1.25$ kg. (= 0.078 lb. of steam per 1 cu. ft. of gas).

Gas consumption per hour $= \frac{3000}{1.25} = 2400$ cbm. = 84,800 cu. ft.

Flue gases per hour $= 2400 \times 1.776 = 4260$ cbm. = 150,000 cu. ft.

Power consumption at the fan $= \frac{1.51 \times 600 \times 10{,}000}{75 \times 0.5 \times 9400} = 25.7$ h.p.

Steam consumption at the fan $= 25.7 \times 9 = 231$ kg. = 508.2 lb./hr. $= \frac{231}{3000} = 7.7$ per cent.

Corresponding gas loss for the fan $= 7.7 \times 0.924 = 7.1$ per cent.

The author expresses some skepticism both as to the published data concerning the efficiency of the Bone-Schnabel boiler (90 and even as high as 92.5 per cent), and the indicated exceptionally low values for the excess of air used (2 to as low as 0.5 per cent). As regards the latter, the author does not believe that the boiler can work economically with so low an excess of air. The heating value and chemical composition of the gas vary from time to time, and at the same time even with the best regulating devices it is hardly possible to keep absolutely constant at each second the ratio between air and gas admitted. The variation in the chemical composition of the gas is of great importance inasfar as it affects the excess of air requirements. Assume, e.g., that in coke oven gas the percentage of hydrogen increased at the cost of that of nitrogen and carbon dioxide; to produce complete combustion, the amount of air present would have to be increased, and if this does not take place (and it will not, since the partial vacuum behind the air regulating valve does not change), there will be a certain amount of methane and hydrogen which will escape unconsumed (unless there is a large excess of air present). The losses in this case will be particularly large because, first, the volume of the gas flowing will increase on account of the

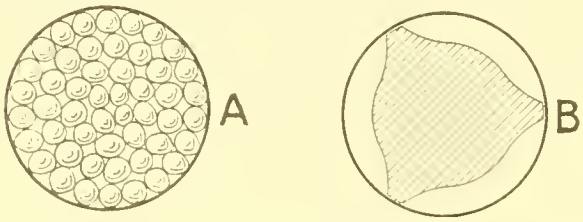


Fig. 8 Surface Combustion Boiler, Heating Tubes, Bone-Schnabel and Neumann Types

reduction of its specific weight, and, second, as often happens in practice, this condition may coincide with a rise of pressure in the gas mains. The Bone-Schnabel boiler requires therefore approximately the same excess of air, say 15 to 25 per cent, that other boilers do.

Tables 2 to 6 have been calculated by the author on the following assumptions. The resistance which the exhaust fan has to overcome has been assumed to be equal to 550 mm of water in the case of a coke oven gas boiler and 600 mm for a blast furnace boiler (an excess of air of 25 per cent is assumed). The heating values and specific weights of the gases are taken from the German engineering handbook "Hütte"; the moisture in the air and gas is neglected throughout. In order to be on the safe side, a loss of 2.5 per cent due to unconsumed gas residue is assumed for the case of an ordinary boiler heated by coke oven gas. Table 6 shows that thermally the ordinary boiler is equivalent to the Bone-Schnabel boiler with blast furnace gas fuel, and slightly superior to it with coke oven gas as a fuel, this notwithstanding the fact that the values for the surface combustion boiler are the highest possible with an installation and draft fan of great perfection, while the ordinary type of boiler may be improved, e.g., by elimination, in the case of coke oven gas fired boiler, of the 2.5 per cent loss through incomplete combustion of the gas. The situation is still less favorable to the Bone-Schnabel boiler when the old and new types of boilers are compared from the standpoint of economic efficiency. Up to the present time the first cost of the Bone-Schnabel boiler has been somewhat higher than that of a corresponding water tube boiler, and, in addition to that, the new boiler has been made so far only in comparatively small units, is difficult to regulate with respect to load and does not produce directly superheated steam; if auxiliary appliances for making the latter are introduced, then the slight advantage in space-demand, as compared with the water tube boiler, is entirely lost. As regards safety of operation, the author objects to the high specific duty of the heating surface, especially with regard to water circulation, and the inaccessibility of the heating surface in contact with water. The final extraction of heat from the flue gases appear to be more economical when

TABLE 4 ORDINARY TYPE OF BOILER WITH COKE OVEN GAS FIRING AS IN TABLE 2

	Per Cent
Flue gas losses 1753 x 160 281 WE	7.8
Radiation and conduction	3.5
Unconsumed gas residues	2.5
Steam consumption for suction draft	1.0
"Thermo-technical" efficiency	85.2
	100

TABLE 5 ORDINARY TYPE OF BOILER WITH BLAST FURNACE GAS FIRING AS IN TABLE 3

	Per Cent
Flue gas losses 0.548 x 160 88 WE	10.2
Radiation and conduction	3.5
Steam consumption for suction draft	1.0
Efficiency	85.3
	100

TABLE 6 "THERMO-TECHNICAL" EFFICIENCY WITH DIFFERENT AMOUNTS OF EXCESS AIR

(in per cent)

	Blast Furnace Gas		Coke Oven Gas	
Excess of air	25	15	25	15
Ordinary boiler	85.3	85.7	85.2	85.8
Bone-Schnabel boiler	85.3	86.2	88.4	89.1
Difference in favor of the Bone-Schnabel boiler	..	0.5	3.2	3.3

done in the preheater than in the boiler, so that in this respect too the new boiler does not offer any particular advantages. Even though many of these objections may be obviated by future improvements, the author believes, from his theoretical considerations, that the surface combustion is not likely to drive out of business the modern well kept boiler plant.

Concerning the Taylor System (*À propos du système Taylor,* Ch. Frémont. *La Technique moderne,* vol. 7, no. 9, p. 301, November 1, 1913. 7 pp., 10 figs. *dh*). From historical references quoted by the author it appears that careful tests in time setting have been made as far back as the seventeenth century, while Bélidor, an engineer who published a book on hydraulic engineering in the middle of the eighteenth century, gave in his work a time rate for driving piles exact to seconds, having, e.g., determined that to drive a pile 16 ft. deep into a certain kind of ground will require 185 min. 34 sec. Dynamometers to measure the effort of a workman have been built by Leonardo da Vinci, and, of a more elaborate type, in the eighteenth century. As regards the present application of the Taylor system in

France, the author expresses the belief that the difficulty lies in the lack of engineers thoroughly trained in their specialty, the encyclopedic character of French engineering education being unsuitable for the formation of engineers possessing a complete knowledge of every detail of the operation, such as the application of the Taylor system requires.

ENGINEERING SOCIETIES

AMERICAN GAS INSTITUTE

Annual Meeting, October 1913

Design of Surface Combustion Apparatus, Charles Edward Lucke.

The paper deals with the development by the author of practical gas-burning apparatus to utilize the process known as *surface combustion*. The new process involves the thorough pre-mixture of the air and gas in the proportions necessary to supply exactly the required amount of oxygen for the combustion reaction. This premixture of air and gas in combining proportions at once removes two important sources of loss in combustion: that due to excess

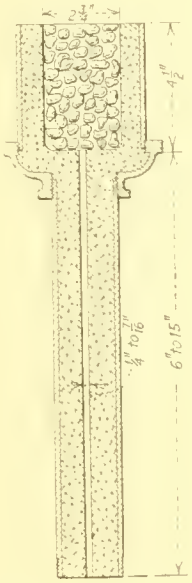


Fig. 9 Type of Burner Used for Determining Size and Length of Feed Holes

air and that due to incomplete combustion. Another advantage follows, also, of no less importance in that it is possible to produce a large part of the heat of combustion in radiant form, the superior advantage of which has long been recognized by physicists. Since the air is supplied in correct proportions initially, the combustion is entirely independent of the atmosphere into which the products discharge and can be carried on behind layers of solid granules, in the crevices between them, behind plates of any convenient form, or with any similar devices, which thus attain the temperature of the products of combustion and radiate heat.

Various problems are encountered in attempting to design apparatus to accomplish surface combustion. Under the conditions the combustion is instantaneous and almost explosive with the result that the flame tends to travel instantly to the point of pre-mixture of the air and gas and thus away from the point of heat application. As a basic principle, the localization of the combustion zone must be attained by providing a means for delivering the mixture of air and gas to the desired combustion point at a rate higher than the normal speed of flame propagation in the mixture. This is accomplished by using small tubes or holes for the delivery of the mixture to the fire zone at a high velocity and an enlargement of the area near the fire zone in which the velocity of the mixture drops to that of the flame propagation.

The line of development has been from the simpler apparatus consisting of narrow tubular passages with conical expanding openings at the ends for the flame zone, to more

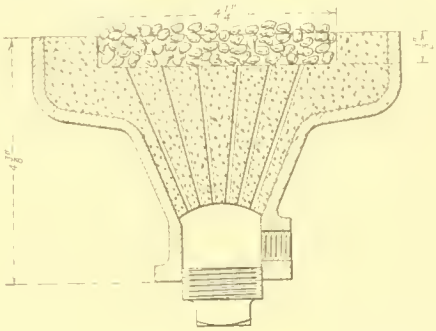


Fig. 10 First Design of Burner with Multiple Feed Holes in which Location of Combustion is controlled

elaborate devices embracing means for more positively localizing the zone of combustion in the form of baffles of such formation as to assist the spreading of the mixture streams beyond the point of high velocity supply; these take the form of refractory granules so arranged in the expanding combustion zone as to counteract the natural tendency of gas jets to remain intact and resist sidewise expansion, and by means of this combination, it is possible to secure a very

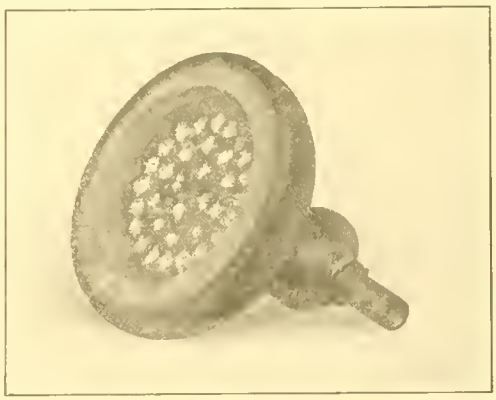


Fig. 11 Top View of First Successful Cook Stove Burner with Multiple Orifices

high degree of incandescence, higher in fact than is possible by any other means using air and the same gas.

The investigations show that the baffling material should consist of pieces of not less than about ⅛ in. diameter and that the feed orifice should be in refractory material since if metal is used there is a tendency to heat and pre-ignition may occur. The feed passages should be of uniform bore and of a diameter corresponding to their length. For instance, a 1/16-in. feed hole 1½ in. long was operated indefinitely with a supply pressure of the mixture as low as 0.2 in. of water; and similarly a ¼-in. hole 6 in. long could

be operated indefinitely with a supply pressure of the mixture at 1-in. water pressure. A 7/16-in. feed hole allowed the flame to flash back to the mixing chamber with a supply pressure of 1½ in. water pressure, even when increased in length to 15 in.

The second important problem is the control of heat generation so that the burning mixture may be distributed over surfaces as large or small as demanded and of the required degree of incandescence. In an effort to determine the maximum possible rate of combustion over a given area, a burner with an area of surface of only 6 sq. in., Fig. 9, was tested with different combinations of feed holes and supply pressure with remarkable results; beginning with a single feed hole 5/16 in. in diameter, the trials were carried to a combination of four feed holes and a supply pressure of 10½ in. of water, which corresponded to a rate of combustion of 2460 cu. ft. of gas per sq. ft. of bed per hour, with a corresponding calorific value of 1,584,000 B.t.u. per hour per sq. ft. Even with this there was no indication that the limit of rate had been reached, but this rate was so high as to give trouble with the available refractory materials at hand. The conclusion was that rates of combustion higher than have ever been known before are easily obtainable, and higher, in fact, than any refractory material in common use can resist.

A greater difficulty, however, was experienced in determining the form of apparatus and conditions necessary to secure low rates of combustion over a bed with uniform incandescence at the surface. The lower the supply pressure of the feed mixture the closer the combustion surface will locate to the feed hole with corresponding tendency of the flame to flash back to the mixing box.

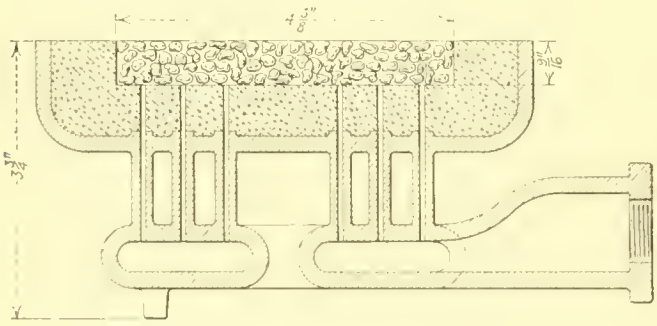


Fig. 12 Improved Form of Burner with Feed Holes so Formed as Effectively to Prevent Back Heating

An arrangement of multiple orifices was finally adopted with feed tubes extending through a considerable depth of the refractory lining of the hearth and so spaced as to give the heat distribution desired at the available pressure. Back heating was controlled in the burner of this design by arranging the feed holes through the refractory lining so that they radiate from practically a center at the feed box to points of even distribution over the fire bed and such a disposal of the burner casing around the lining as to facilitate the radiation of heat from the lining at these points to the atmosphere, Figs. 10 and 11.

From the large number of burners that were built and subjected to practical tests, a design was finally evolved which differs from that above described only in that the multiple feed holes pass down from the lining into and through separate legs or stems formed in the base of the iron burner casting, from which free radiation of heat to the atmosphere is possible. This form of burner, Figs. 12 and 13, provides sufficient cooling of the feed holes to render a flash-back practically impossible.

The third important division of the problem is the matter of control and adjustment of radiating surface, namely, the provision of means for adjusting the rate of combustion of any burner from minimum to maximum, and to operate safely and surely with one adjustment no matter what the

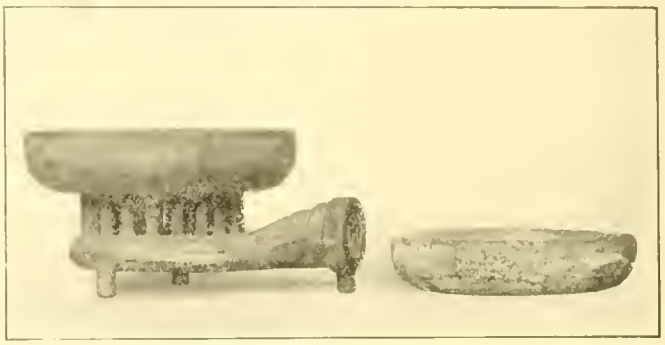


Fig. 13 View of Improved Burner Showing Arrangement of Individual Stems to Effect Positive Cooling of Feed Holes

previous adjustment or the time of operation. The range of control of rate of combustion depends primarily on the size of feed holes and on the effectiveness of cooling them by radiation of heat from the metal casing. With holes 1/16 in. in diameter in cook stove top burners, broilers and room heaters, it was found that they can be safely operated at 0.2 to 0.3 in. pressure and that at least as great a range of adjustment can be obtained as is possible with the Bunsen burners of the ordinary form without flash back. The time of heating is likewise within control by varying the thickness of the bed of refractory material.

The experiments led to the development of the successful form of quick heating top burner which becomes incandescent at the normal rate of combustion in about half a minute, and it is doubtful whether this time can be reduced, since a limited amount of heat storage is necessary to resist the effect of spilling water or grease upon it, and for intermittent work such as heating laundry irons, which may absorb heat for a time faster than generated. The burner is formed by countersinking the outlet side of the 1/16-in. feed holes to ½ in. and filling the conical holes thus formed with silica in sizes from 5/32 to ⅛ in. and aso covering the entire hearth to a depth of about ¼ in. as indicated in Fig. 14.

A fourth problem relates to the development of the necessary auxiliary apparatus for operating the burners, such as supply cocks, pressure-regulating valves, etc. For the surface combustion burner, two valves are necessary for properly adjusting the ratio of air to gas, and as it is undesirable to place the control of two such valves in the hands of inexperienced operators, a double ported mixing valve has been developed as is shown in Fig. 15, in which is provided a single handle that controls both gas and air pressure supplies, and also means for the adjustment of the air opening for proper proportionment of the ratio of air to gas. This latter is accomplished by the hand wheel at the bottom of the valve which adjusts the air plug axially and so varies the opening of the air port.

An essential for satisfactory working of a double ported

cock of this type is equality of pressure of both air and gas and to provide for this, a diaphragm regulator was found necessary in order to avoid serious interference with the mixture proportions due to excess of pressure on one side or the other. The regulator is so constructed that the pressure of the gas is utilized to manipulate a damper valve in an air supply connection, by means of which increase of pressure in the gas opens up the passage in the air connection and vice versa.

The efficiency of surface combustion appliances compared with Bunsen type burners varies with conditions and for

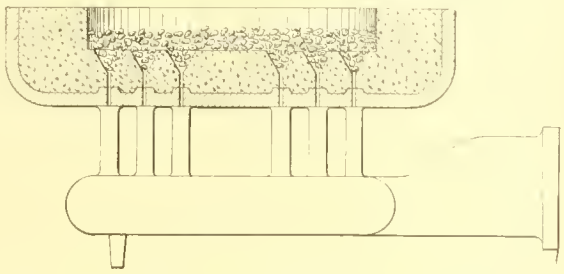


Fig. 14 Modification of Improved Type of Burner that Allows Quick Initial Heating

this reason the author gives figures based on a limited scope of experiments confined to domestic appliances operating on city gas, all of which were formed by removing the Bunsen burners from standard commercial appliances and substituting the surface combustion burners. Top burners were tested by observing the consumption and time to raise a weighed body of water from an initial low temperature up to 200 deg. fahr. with fire beds of various materials and thicknesses, different sizes, shapes and materials of vessels, differing distances between flame and vessel, on all sorts of gas and mixture pressures, etc. It was universally found that with conditions as nearly identical as possible, the surface combustion burners will accomplish an equal amount of heating with less gas than the Bunsen burners, although the relative economy seems to be dependent upon the construction of the burner, the stove and the water vessel.

In one series of tests, a surface combustion burner, with 4⅜ in. hearth with 5/16 to ⅜ in. refractory material, ½ in. deep, and covered at the edges by a cast-iron ring with vents between it and the vessel, was tested in comparison with a Bunsen burner of standard construction consuming 15 cu. ft. of gas per hour. In both cases these burners were turned down to a simmer, and it was found that the consumption of gas necessary to keep the water just below boiling point was 5.2 cu. ft. per hour for the Bunsen burner and 2.42 cu. ft. per hour for the surface combustion burner, a ratio of 2.15. In another series, with a standard Bunsen burner and a surface combustion burner with a thick silica bed surface, the ratio of consumption of the gas varied between 1.71 and 1.75. In the latter, when by a slight change the burner was converted into a quick heating design, the ratio was raised to 1.80. In numerous other tests, this ratio decreased according to conditions, and in one case went as low as 1.2, but in all cases of these low ratio results, it was found that the surface combustion burners were either of inefficient design for the purpose or improperly applied; under favorable conditions involving the application of an efficient type of burner and the most advantageous conditions of transfer of heat to the vessel it was found that the surface combustion appliances operated with a consumption of gas about one-half that of the standard Bunsen burner when under continuous operation. For intermittent work the saving is not nearly so favorable.

With this system, however, the cost of operating the fan for producing the air pressure must be taken into account. Assuming the case of a domestic range with a burner operating 3 hr. per day and 300 days per year, at an average rate of 50 cu. ft. per hour, the surface combustion burner operating at an average saving of 40 per cent over a corresponding Bunsen burner, would effect a saving in cost of gas of approximately $30 per year. The cost of operating the fan under the most unfavorable and inefficient conditions would not greatly exceed $8 for 900 hr. of operating for the year. This makes the net saving in operation about $22 per year.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Vol. 39, no. 9, November 1913, New York

Painting Structural Steel: The Present Situation, A. H. Sabin (Abstracted)

Stresses in Wedge-Shaped Reinforced Concrete Beams, W. Cain

Painting Structural Steel, A. H. Sabin (6 pp., to be presented at the meeting of the Society January 7, 1914. *p*). After several attempts to classify paints, a committee of five chemists from different parts of the United States, with the approval of the American Society for Testing Ma-

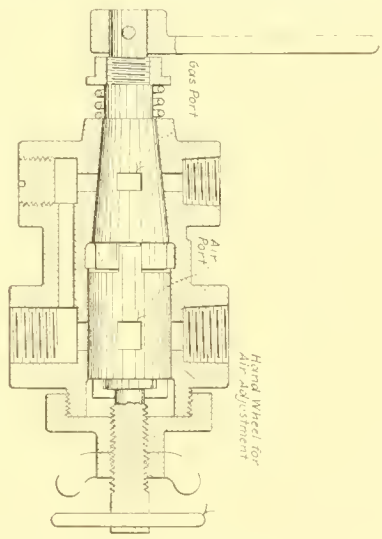


Fig. 15 Details of Double-Ported Mixing Valve with Adjustment for Ratio of Air to Gas

terials, made a series of tests of the principal pigments, and of some other substances, on steel immersed in water, and arrived at concordant results. In the report of this committee the pigments were classified, *according to their water value,* into three groups, namely, inhibitors, indeterminates, and stimulators. While it was expressly stated in the report that this was a classification as regards water only, the names (partly through ignorance, partly owing to their apparent convenience for advertising purposes) came to be widely used to classify pigments in oil, which is misleading, since any classification of pigments in oil should be based on their behavior in oil, usually radically different from that in water.

The important practical question is whether paints have been or can be improved as to being non-porous and dur-

able. This is essentially dependent on the relation between the pigment and the oil. As to the true nature of this relation, very little is known; but something is known about its visible manifestations. Thus, 1 lb. of dry red lead mixed with ¼ lb. of oil makes a paint of ordinary consistency, but a pound of dry lamp-black requires many times as much oil; white zinc takes twice as much oil to make a paint as white lead, the latter in its turn taking nearly twice as much as red lead. While these facts are known, there is no information as to why it is so. As to red lead paint, it is now known that its value depends on the quantity of red lead proper it contains, as compared with that of litharge. Coarse red lead always contains litharge, because the litharge in the middle of a large particle is never oxidized. Manufacturers are therefore grinding their litharge to an impalpable powder before roasting it, with the result that now paint with 94 per cent of true red lead is on the market. Unlike the old paint which worked with difficulty and unevenly in application, the new article is inactive in oil, and brushes out smoothly like a house paint. This enables the painter to cover 50 per cent more surface with the same quantity, and still get a coating of uniform thickness which gives more protection than the thin portions of the paint formerly used. In addition to economy in the cost of paint and labor, there is the further advantage that less skill is required and therefore a lower salaried man may be employed. Red lead paint is now offered as a paste ready to be thinned with more oil; such a paste keeps for a year or more, and gives a better mixture than hand-mixing, as well as eliminates the presence of a dusty pigment. Such red lead dries more slowly than the older kinds, but this can be obviated by the use of a little japan drier; only 1 pint of drier is needed to make 1 gallon of mixed 94 per cent red lead, anything above that proportion being excessive and objectionable.

Important work is also going on with respect to standardization in the use of linseed oil, specifications having been adopted by the American Society for Testing Materials for North American raw linseed oil, which is of better quality than that made from South American seed. From tests made by the American Society for Testing Materials on the Havre de Grace bridge, the author concludes that the durability of any good paint may be increased one-half, and probably doubled, by proper care in its use as compared with average practice.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Vol. 25, no. 3, August 1913, Washington, D. C.

U. S. S. "Cassin" and "Cummings": Description and Trial Performances, Henderson B. Gregory
The Saving of Heat Units in Marine Machinery, Henry C. Dinger (Abstracted)
Chemical Indicators in Volumetric Work: Preparation of Normal Solutions, and Determination of Chlorine in Boiler Water, H. T. Dyer
The United States Naval Engineering Experiment Station, Annapolis, Md., E. J. King
Description of Nürnberg Two-Cycle 450-B.H.P. Heavy Oil Engines, Louis Shane
An Analysis of Crankshaft Stresses: Determination of Stresses in Two- and Three-Bearing Four-Cylinder Crankshafts, K. W. Najder

The Saving of Heat Units in Marine Machinery (p. 379, 22 pp., 2 figs. *cd*). From data based on trials of the *Delaware, Michigan, Utah* and *Florida*, the author advocates the combination of reciprocating engines for the high pressure end and turbines for the low pressure end, with reheaters and series feed heaters as an additional means of saving heat. By the combination of reheaters and series feed heaters a reduction in the average fuel consumption of from 5 to 10 per cent can be made, at a cost and added weight that, considering total weight and cost of plant, is almost negligible. In the future, the author expects to see electric motor drives on the shafts with the current supplied partly by Diesel engines and partly by steam turbines, with several generating units of each type. The exhaust from the oil engine could be utilized to assist in the generation of steam in the boilers, and the feed water for boilers might be used as the cooling water for the oil engine. Such a combination, in addition to its high economy, would enable the propellers to be operated by either the oil engine or the steam turbine. This requires, however, an entirely reliable engine that can be operated satisfactorily on ordinary fuel oil, either asphalt or paraffine base. The heat requirements of the auxiliaries are fully discussed.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Vol. 29, no. 7, October 1913, Pittsburgh

The Use of Pulverized Coal in Metallurgical Furnaces, James Lord (Abstracted)
Composition Flooring, H. M. Hooker (Discussion)

The Use of Pulverized Coal in Metallurgical Furnaces, James Lord (53 pp., 7 figs. *deA*. A short bibliography of the subject attached). Pulverized coal has been used now for more than ten years. From the first it was apparent that its economical use depended upon the absolute control of the feed by the burners. Success in the use of this fuel requires (*a*) that both the free and combined moisture be expelled by artificial heat, down to 0.5 per cent; (*b*) that at least 95 per cent of the pulverized matter should pass through a 100-mesh sieve, and over 80 per cent through a 200-mesh sieve. The delivery to the furnace must secure proper feed, and when used in metallurgical furnaces, the coal should have a high volatile content. The equipment of the Lebanon plant of the American Iron and Steel Manufacturing Company is such that the slack coal is conveyed automatically from the coal to the pile, then taken by screw conveyors to the dryers, and in the same manner from the dryers to the pulverizers. It is not touched by hand or shovel from the freight car to the furnace. At the end of each line, there should be an overflow pipe to prevent the coal from choking up the screw, if anything should happen to the crosslines. Otherwise should the coal overflow near an open fire, it will burn back very quickly. To each of the furnaces is attached a hopper carrying about 15 hours' supply of pulverized coal. On several occasions the fuel has ignited in these hoppers, but it was only necessary to stop the supply and to feed the burning coal into the furnace until the tank was emptied. There is no danger of explosion under these conditions, and during the entire experience of the author with this fuel he has had no explosions. Proper attention to the pulverizing plants and machinery will eliminate the only possible danger from coal in suspension in a room coming into contact with flame. It is, however, dangerous to have the dryer in the coal pulverizing house, for the reason that if an accident should occur, causing the coal to overflow, it might be drawn into the fire chamber of the dryer with possible injury to employes. Further, the department in which the coal grinding is done is usually dangerous, for it is almost impossible to grind

coal without having dust escape, but a change of air should minimize the possibility of explosions, which can also be achieved by the use of exhaust fans.

As regards the grade of coal that can be used, coal piles are not suitable, as they are mostly anthracite and dirt. The great difficulty of low-grade coal is the deposition of slag, which requires frequent opening of the furnace front to attempt removal, which is not always so easy. The best coal obtainable should be used, at least until all the details of operation have been fully perfected.

As to the need for drying coal, the author states that dry coal is very desirable, but it is a matter of first cost; and with limited capital for first installation, wet coal may be used successfully. Where it is used, an igniting flame is to be provided.

Design of Furnaces using Pulverizing Coal. The first essential of a pulverized coal furnace is a large combustion space, where the flame can occupy about four times the volume of the flame produced by an ordinary grate fire. This entire combustion space must be free from any metallic cooling surface, which stifles the flame and stops combustion. Any mechanism which will give a uniform mixture of coal and air with both under control can be used for feeding pulverized coal. Powdered coal flushing must be guarded against, since this kind of coal will run almost like water. The screw feeding the coal, however, is usually made very long, so as to introduce enough friction to keep back the flush of coal. The air used in the pulverized coal burner has been greatly reduced from 20 lb. on cement furnaces of the early days to about ½ oz. on metallurgical furnaces. Powdered coal is very destructive to the life of the furnace, owing to the tendency of concentrating the heat in an action similar to that of a blow-pipe, the wearing effect being due to the impingement of the coal, and the tendency of the ash and brick to flux together. The later designs of furnaces prevent this somewhat by the use of low-pressure air introducing the coal at a very slow velocity, and spreading the flame over as large an area as possible.

TABLE 7 COST OF PULVERIZING COAL

Capacity of Grinding Room, Tons per Hour	Finished Product through 100-Mesh Screen, Per Cent	Horsepower at ¾c. per Kw-Hr.			Labor		Cost per Ton for Maintenance, Cents	Total Cost per Ton, Cents
		Total	Hours per Ton	Cost per Ton, Cents	Men at $2, per Day	Cost per Ton, Cents		
2	95	45	22.5	11 25	1	10 00	3 33	24 58
3	95	60	20.0	10 00	1	6 65	2 22	20 88
4	95	75	19 0	9 50	1	5.00	1 70	16 20
5	95	85	17 0	8 50	1	4 00	1 20	13 70
10	95	170	17.0	8.50	1	2 00	1 20	11 70
25	95	425	17 0	8 50	2	1 70	1 20	11 40

As to economy, the economy over oil is fully established. As compared to producer gas, it is expected that equal economies will maintain. Where checker work and ash troubles are objectionable, producer gas will be preferred, but where the ash can be taken care of, there seems to be a saving by the use of pulverized coal amounting to about 25 per cent.

In the discussion which followed, H. R. Barnhurst of the Fuller Engineering Company described the two methods by which pulverized coal may be burned. The first may be called "the long flame method." It is a progressive burning of the coal used where the character of the work and form of furnace demand that the flame shall be elongated so that the heat may be developed in close proximity to the work done, and not conveyed by gases from the initial point of firing. The high velocity air jet is used with this method of burning.

The second method involves a shorter flame and lower velocity, both of air and coal. It has less cutting action upon the charge or brickwork, and the fuel burns close to the nozzle developing through the whole fuel cloud almost instantly. The second method has been the latest developed, and appears to be the most promising.

The long flame method is employed in the cement kilns, but is not adapted to the various heating furnaces, nor to use under boilers. The speaker gave a very interesting table of calculated temperatures attained in burning carbon which showed that with slight excesses of air, temperatures in close proximity to 4000 deg. fahr. may be attained. He also gave step by step the mechanical processes of pulverization.

How far savings may be obtained by the use of pulverized coal was shown by E. W. Shinn, who stated that the American Iron and Steel Manufacturing Company was installing a plant in connection with open-hearth furnaces which were now using oil as a fuel, and where a $32,000 investment would save $100,000 per year.

A. W. Raymond gave some interesting data on the cost of pulverizing the coal gained from experiments and tests of several large users, for which see Table 7. This table shows that the larger the quantity of coal handled in the milling plant, the smaller the cost per ton for pulverizing, which applies to all other operations as well. The total cost for preparing the coal in a plant having a capacity of 5 tons per hour or more will not amount to over 35 cents per ton (the speaker gave in detail how he arrived at this figure) and in a great many cases in the cement industry in the United States this has been brought as low as 28 cents.

Use of pulverized coal under boilers. E. W. Shinn stated that it was applied to boilers by the American Iron and Steel Manufacturing Company, but the boiler settings were not altered to suit that changed requirement, and consequently the conditions were not of the best. They succeeded in evaporating about 8½ lb. of water per lb. of coal used.

A. Stucki stated that a local plant obtained an actual evaporation of 10½ lb. of water per pound of pulverized coal. He made an investigation of a plant in the Pittsburgh district which started to use pulverized coal, and found the fuel economy good; there was absolutely no smoke, but nevertheless the system was soon abandoned. The reasons for doing so were as follows: The heat which was obtained by blowing the coal dust from opposite sides, and letting the two flames meet in the center of the firebox, was very intense and very hard on the firebox lining and the firebox in general. The first cost of the dryer, the mill, the blowers, the conveyors and the feeding apparatus was considerable. Large additional floor space was needed, while the upkeep of all this additional machinery was considered unfavorable; the power necessary to drive the additional machinery was about 5 per cent of the power produced. Finally, the danger of leaks in the conveyors and consequent danger of explosions was also considered objectionable.

INSTITUTION OF ELECTRICAL ENGINEERS

Vol. 51, no. 220, June 1913, London

Power Supply on the Rand, A. E. Hadley (Abstracted)
Independent Steam Condensing Plants, W. A. Dexter
Air-Cooled Jacketing in Hollow Walls by Electric Fans, J. W. Mears

Power Supply on the Rand (p. 2, 56 pp. *d*). Description of the power generating system of the Victoria Falls and Transvaal Power Company, Ltd., operating both hydro-electric and steam power, and selling compressed air in addition to electric power. The Prat ejector system of induced draft is used throughout, adjacent boiler units being connected to a common ejector chimney, the top of which, in the Rocherville station, is only 90 ft. above the boiler house floor; an electrically-driven rotary fan blows cold air through the ejector chimney, thereby producing the necessary suction in the flues, with a torpedo-shaped damper in the air-pipe regulating the pressure of the air jet. Although a small coal mixed with duff produced by the coal cutters is used, the plant is absolutely smokeless. Babcock & Wilcox marine type boilers with chain grate stokers are used, each having an integral superheater and economizer.

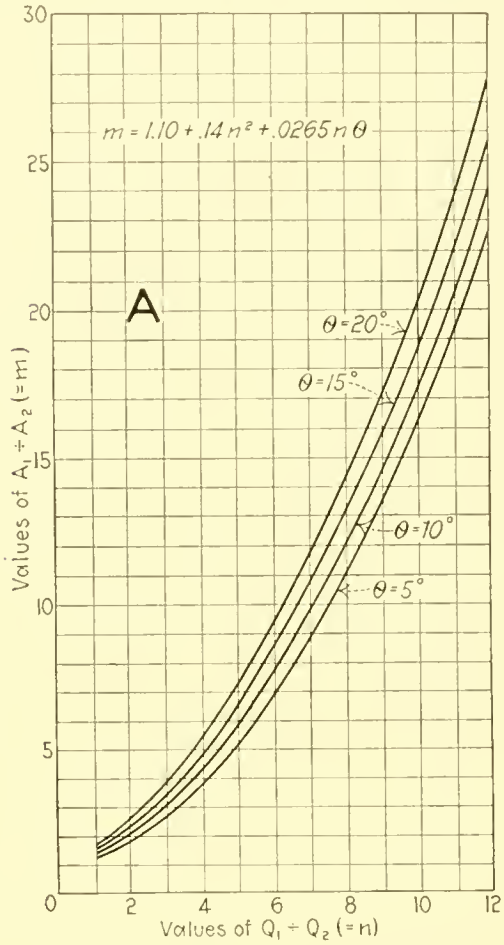


Fig. 16A Values of *m* Giving Minimum Loss

As the consumers participate in the profits, they have at definite periods a right of access to the books in order to determine the cost of a unit of power. The form in which the returns from each station are made, is based upon the underlying idea of energy expressed in kilowatt-hours. The energy value of each pound of coal, usually expressed in B.t.u., is converted to kilowatt-hours by multiplying by 0.000293; thus a coal of 11,300 B.t.u. per lb. has a value of 3.3 kw-hr. per lb. In a similar manner the energy in the steam is calculated from Mollier's steam tables, the boiler efficiency being the ratio of the kw-hrs. in the steam (less the energy supplied from the hot well) to the kw-hr. in the coal. Other efficiencies are calculated in a similar manner.

The compressed air system, probably the largest of the kind in the world, is described in detail, as well as the air meters and measurements adopted. Compressed air is supplied to the various mines at an average pressure of 100 lb. per sq. in. delivered on the consumer's property; the maximum load is nearly 60,000 kw.; the distance between two extreme mines served by the air-pipe system is approximately 14 miles, with the diameter of the pipe varying from 24 in. to 9 in. The air is supplied by two groups of compressors, one steam-driven, and the other electrically driven. At first it was feared that, with such large compressors running in parallel on a common pipe system, the machines unless automatically controlled, would tend to hunt with a variation in load; actually, however, only one or two cases have been recorded of a compressor dropping out to atmosphere, and even this was due to abnormal disturbances in the electric supply system, while the steam driven compressors have operated satisfactorily from the start. As to losses, tests have shown that of the units of air sent out, 95 per cent have been recorded at the consumers' meters, 3 per cent have been lost in transmission, and 2 per cent unaccounted for. The drop in pressure to the various mines varies with the distance and size of pipe, but the average pressure drop is not more than 6 lb. With a monthly air load factor of 50 per cent, the plant appears to be a success financially.

INSTITUTION OF MECHANICAL ENGINEERS

No. 2, 1913, London

Some Effects of Superheating and Feed-Water Heating on Locomotive Working, F. H. Trevithick and P. J. Cowan.
The Design of Volute Chambers and of Guide-Passages for Centrifugal Pumps, Professor A. H. Gibson (Abstracted)
An Improved Governor for Water Turbines, Percy H. Pitman
An Electrical Measuring Machine, P. E. Shaw

The Design of Volute Chambers and of Guide-Passages for Centrifugal Pumps, A. H. Gibson (p. 519, 45 pp. *etA*). The paper is based mainly on data obtained from recent experiments at University College, Dundee. The author in another publication has established the following formula for the loss at impact of impinging streams, only one of which is deviated by the impact

$$\text{loss} = \left\{ a\left(\frac{n}{m}\right)^2 + b \right\} \frac{v_2^2}{2g} \text{ ft-lb. per lb} \ldots [1]$$

where v_1 is the velocity of the primary (undeviated) stream; A_1 area of the same stream; v_2 velocity of the impinging (deviated) stream, and A_2 its area; θ angle of impact; $m = A_1 : A_2$, and $n = Q_1 : Q_2$, the latter being the volumes, in cu. ft. per sec., conveyed by the two streams. The author found experimentally also that the old formula

$$\text{loss} = \frac{(v_2 \sin\theta)^2 + (v_2 \cos\theta - v_1)^2}{2g} \text{ ft-lb. per lb} \ldots [2]$$

is quite inaccurate. What follows is based on the assumption that the state of affairs during the impact of each of the streams leaving the impeller of a pump is analogous to that in a single stream impinging under the same conditions

as to direction and velocity. If v_d be the velocity of flow along the discharge pipe of a pump, and the loss of energy proportional to $(v_1 - v_d)^2$ be also taken into consideration (experiments on flow in diverging passages have previously established that if the sides in a circular pipe diverge at an angle of 6 deg., the loss of head including friction is about $0.13(v_1 - v_d)^2 : 2g$, and is greater for angles greater or less than 6 deg., amounting to $0.15(v_1 - v_d)^2 : 2g$ for usual angles of divergence in the volute chambers of pumps); let further $v_1 : v_d = 3.85$, which is in close agreement with practice, then the total increase in pressure energy after leaving the impeller is given by:

$$\frac{v_1^2}{2g}\left[(1-b)-\left(\frac{n}{m}\right)^2\left\{0.15+a\right\}\right] \text{ ft-lb. per lb.} \ldots\ldots [3]$$

where m is the ratio of the cross-sectional area of the volute at the point under consideration, to the area of the stream leaving the impeller, and the values of a and b are given by the formulae:

$$a = \frac{0.0052}{m}\theta^{1.25}(\theta \text{ in deg.})\,;\; b = \left(\frac{m-1}{m}\right)^2 + \frac{0.00046}{m}\theta^{1.5} \ldots [4]$$

If the ratio $Q_1 : Q_2$ $(= n)$ be known, the known values of a and b enable the value of m for maximum gain of pressure to be calculated by successive approximations. To facilitate the solution of practical problems the range of values of θ from 0 to 20 deg. and of m from 1 to 28 have been examined in this way, and it appears that the value of m for maximum gain of pressure is given with a close degree of accuracy by the relationship:

$$m = 1.10 + 0.14n^2 + 0.0265n\theta \ldots\ldots\ldots [5]$$

where θ is expressed in degrees. The best values of m for different values of n and θ are shown graphically in Fig. 16 A, while B shows what fraction of the kinetic energy of discharge is converted into pressure energy with these best values of m.

In the volute chamber, Fig. 16 C, let θ be the angle of impact of each of the discharging streams; N number of vanes or passages in the impeller; γ their discharging angle; r the radius, and b the breadth of the impeller at its outer periphery. The effective area of each of the impinging streams, normal to its direction of flow, is $\frac{2\pi rb}{N}\sin\theta$ (neglecting the space occupied by the vanes), and the area of the volute at this point for minimum loss is

$y =$ (effective discharge area of each passage) $\times m$

m being that of formula [5], or of the curves of Fig. A. From an examination of curves Fig. B, and a table showing the proportion of kinetic energy of discharge which may be converted into pressure energy with a volute of best form, the author deduces that in a pump of this type, the smaller the number of vanes, the more efficient the corresponding volute, and other things being equal, the pump also, with the qualification that too few vanes give insufficient guidance to the water, and increase the tendency to the formation of circulatory currents behind the discharging edge of each vane. The author supports this view by referring to the Wisconsin experiments (Bulletin, University of Wisconsin, 1907, No. 173).

The experiments at University College, Dundee, were made with a pump having a single encased impeller of diameter 13.5 in.; breadth 0.5 in.; $\gamma = 30$ deg.; having ten vanes and designed to discharge 425 gal. per min., at 1250 r.p.m., against 85 ft. head, and circular section of volute as shown in Fig. D. The cross-section was varied, first, by filling in the spaces S_1S_1 by plaster of paris (experiments a), and then by filling up the space S_2 with a wooden strip bent to shape (experiments b and c). The areas of the volute at sections A, B, C, D (Fig. C), 90,180,270,360 deg. from the cutwater respectively, are given in Table 8. Volute a forms a fair approximation to the calculated best form; the original volute is of good proportions towards the outlet D; b is of good form about B, but restricted in area

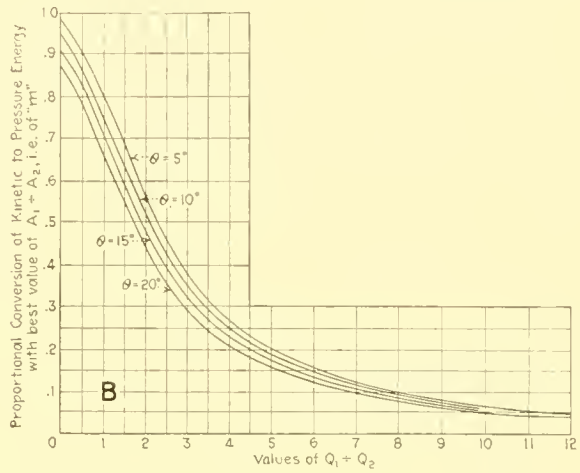


Fig. 16B Proportional Conversion of Kinetic to Pressure Energy

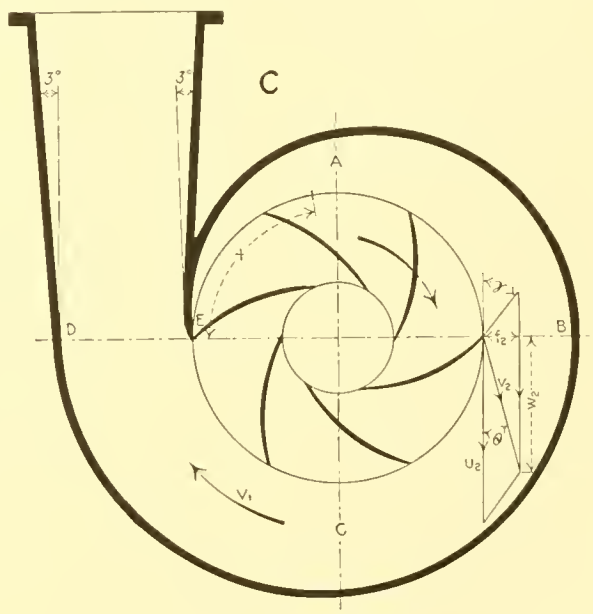


Fig. 16C Volute Chamber

over the latter half of its length; c is still more restricted, while d is considerably smaller throughout than the analysis calls for. The results of efficiency tests with these volutes are shown in Fig. E: a increases the maximum overall efficiency of the pump, as compared with the original volute, by approximately 6 per cent, the efficiency being generally inversely proportional to the difference between the actual form of the volute and that indicated by theory.

The author further compares modern types of volutes and those designed by his analysis, and shows that the most efficient pumps are those showing the closest coincidence between the values calculated and the actual proportions of

volute. In general, he found that the volutes were too large for maximum efficiency. It appears further that, as far as the conversion of energy was concerned, a simple pump of the type described was inherently less efficient than a turbine pump in which the effective number of vanes was equal to that number discharging into each of the guide-passages. This disadvantage might be reduced by a series of guide-

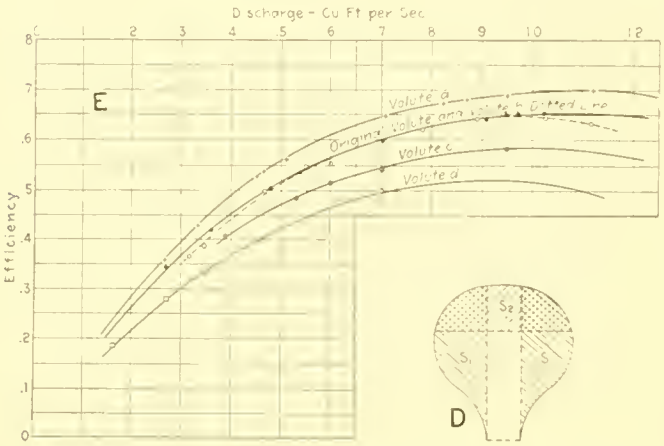


Fig. 16D Volute Used for the Dundee Experiments
Fig. 16E Results of Efficiency Tests with Different Volutes, Dundee Experiments

vanes in the volute (Fig. F), which could be of sheet metal bent to shape and cast in position; they would not cost much, and would increase the possible conversion of energy roughly by 100 per cent.

As to the best form of section for the volute, the author recommends an arrangement of a chamber with parallel

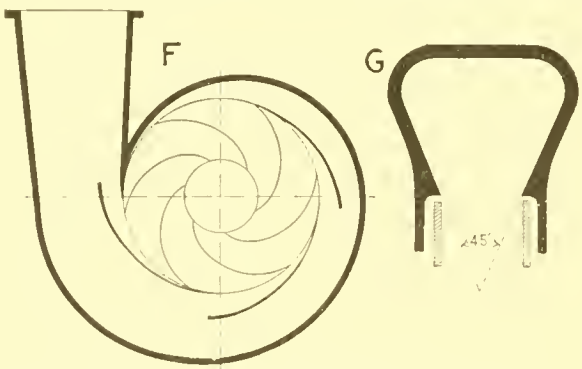


Fig. 16F Volute with a Series of Guides
Fig. 16G Section for Volute, Straight Sides inclined outwards at 22.5 Deg.

sides of the same width as the impeller. It could also be easily machined, and the addition of guide vanes would be comparatively simple. With small pumps, however, it would have a comparatively small hydraulic depth, and its friction losses would on this account tend to be high. Experiments on diverging passages indicate, however, that fairly good results could also be obtained in the average pump with straight sides inclined outwards at about 22.5 deg. (total included angle 45 deg., cp. Fig. G); with this form of section the outflowing streams diverge at about the best angle when moving with their highest velocity, while the interior surfaces can be smoothly finished off with little difficulty. With either form of section, with the best areas the velocity in the volute is usually from three to four times that permissible for flow through the discharge pipes, and, to utilize as much of this kinetic energy as possible, the connection between the volute chamber and discharge pipe should be made by a tapered pipe having walls diverging at about 6 deg., as in Fig. C. The design of guide passages for turbine pumps is also discussed in detail.

In the discussion which followed, A. Marshall Attack objected to the treatment of the theory of pumps from the point of view of a high velocity stream impinging on a lower velocity stream, a very undesirable condition in a centrifugal pump. With impellers having from six to twelve vanes, the writer has not found from practice that the larger number of vanes had a seriously deteriorating effect upon the efficiency of the volute, over 50 per cent of $\frac{v_2^2}{2g}$ being converted in comparatively small pumps. Professor Gibson wrote in reply that the first statement was true, but that every pump fitted with a volute chamber was subject

TABLE 8 AREAS OF VARIOUS SECTIONS OF THE VOLUTE USED IN THE DUNDEE EXPERIMENTS

	Area of Volute, Sq. In., at Point:			
	A	*B*	*C*	*D*
Calculated Best Form	0.79	1.77	3.30	5.36
Original Volute	1.1	2.6	4.1	5.6
Modification *a*	0.87	1.9	3.5	5.5
b	1.1	2.2	3.0	4.3
c	1.1	2.2	2.5	3.0
d	0.77	1.3	1.6	1.9

to this condition, and what was desired was to suggest means of reducing the shock loss which it inevitably involved. The second statement, that over 50 per cent of $\frac{v_2^2}{2g}$ is converted, the writer doubts.

Robert H. Smith recalled the experiments of Professor Inokuty, of the Imperial Japanese University, Tokyo, (for a full text in English see The Technical Papers of Ariya Inokuty, Tokyo, 1913, p. 181 to 280, *Editor*), who, in his investigation assumed that the hydraulic loss in a flow of uniform section and velocity equaled $f\frac{l}{r}\frac{v^2}{2g}$, with l the length and r the mean hydraulic radius of the channel. As a matter of fact, the loss varies neither as v^2 nor as l/r. The latter assumption was made also by Professor Gibson. In reply to that part of the criticism, Professor Gibson states that his experiments on taper pipes have shown that over the whole range of velocities investigated the loss was, within the limits of experimental error, proportional to $(v_1 - v_2)^2$. The most important aim, according to Professor Smith, was to find the value of v_1, which yielded maximum P when other things such as m, θ, v_2 and v_d were fixed by other requirements. By ordinary differentiation, this value was found to be

$$v_1 = \frac{0.15}{0.15 + a} v_d$$

and this value of v_1 yielded the maximum pressure energy

$$2gP_{max} = (1 - b)v_2^2 - \left(0.15 - \frac{0.0225}{0.15 + a}\right)v_d^2$$

This value of P_{max} increases with v_2 directly, and with v_d inversely. This equation makes v_1 less than v_d, and therefore involves a volute chamber of large size. A long and interesting discussion of the paper by Mr. Price is omitted here as it is unsuitable for abstracting.

INTERNATIONAL RAILWAY FUEL ASSOCIATION

Proceedings of the Fifth Annual Convention, May 1913, Roanoke, Va.

Sub-Bituminous and Lignitic Coal as Locomotive Fuel
Firing Practice
Scaling of Locomotive Boilers and Resultant Fuel Losses
Self-Propelled Railway Passenger Cars

Sub-Bituminous and Lignitic Coal as Locomotive Fuel (p. 43, 15 pp. *gp*). The paper describes and illustrates, among other things, several devices for preventing spark troubles that are particularly apt to occur when sub-bituminous and lignitic coals are burned owing to the high drafts necessary to burn them. The following cost data are quoted (results of a dynamometer car test were used as the basis of computation):

Bituminous Coal		Sub-Bituminous Coal	
Price at Buxton, Ia.	$133 83	Price at Hudson, Wyo.	$153 26
Cost to haul to Cody, Neb.	196.26	Cost to haul to Cody, Neb.	171.46
Cost to return empties	54.63	Cost to return empties	47 88
Total cost	$384 72	Total cost	$372 60
Saving in favor of Wyoming coal			$12.12

Scaling of Locomotive Boilers and Resultant Fire Losses (p. 270, 14 pp. *gd*). General discussion of the causes of scaling of locomotive boilers. Contains complete advance data of the experiments on the transmission of heat into steam boilers about to be commenced at the United States Bureau of Mines, in Pittsburg, under the direction of Mr. Henry Kreisinger. The Committee is of the opinion that pure amorphous graphite will be of material assistance to any boiler. By adhering to the plates and tubes, it prevents anything further sticking thereto; it has also a tendency of penetrating into cracks in the scale, and rendering it softer.

NEW YORK ELECTRICAL SOCIETY

New Series, June-October 1913, no. 6, New York

The Flying Boat, Lieut. T. G. Ellyson, U.S.N. (Abstracted)
The Application of the Gyroscope to the Flying Machine, Elmer A. Sperry (Abstracted)
Description of the Elevator Equipment and the Electric Installation in the Woolworth Building, New York City, Charles E. Knox

Safe Flying and the Flying Boat, Lieut. T. G. Ellyson (18 pp., 11 figs. *dh*). The author gives an historical account of the development of the flying boat, and a fairly complete description of the Curtiss boat. At first the propeller was chain driven, the assumption having been that propellers of large diameter and pitch could be used, and hence less power required, with a corresponding reduction in weight, owing to the reduced consumption of gasolene and oil. The chain, however, used to break so often, that the direct-drive propeller had to be adopted. Another interesting feature of the flying boat is the arrangement of the main gasolene tank: to keep the weight as low as possible and to reduce the head resistance, the main gasolene tank (42 gal.) is situated in the hull of the boat, with an auxiliary feeder tank of 8 gal. capacity attached to the side of the engine bed, in order to get a head of gasolene for the carbureter. Gasolene is pumped from the main to the feeder tank by means of a plunger pump driven from the water pump shaft, there being an overflow to the main tank to take care of excess. In case this pump breaks down, a small electric light is automatically lighted as soon as the supply in the feeder tank drops to 4 gal. Then the operator has only to close the vent on the main tank, and put pressure on this tank by means of a hand air pump, so as to force gasolene to the feeder tank. On the whole, the author, who made a number of flights in the Curtiss flying boat, states that the boat is quite easy to handle both in the air and on the water.

Safe Flight and Automatic Stabilization of Aeroplanes, Elmer A. Sperry (13 pp., 16 figs. *d*). The author describes a gyroscopic system of control, and holds that, in addition to all the longitudinal control, in turning curves it produces automatic banking to the point of zero "skid," either inwardly or outwardly. The author describes various apparatus where gyroscopes are used and calls attention to the fact that a single gyro is responsive to all prime components of universal compound motion, and that for purposes of stabilization, only compound gyro equipments must be used, where each gyro is responsive only to motions about a given axis, and entirely unresponsive to motions about every other axis. The Sperry aeroplane stabilizing equipment comprises two separate combinations of devices, one for maintaining longitudinal stability and another for maintaining lateral stability.

The longitudinal stabilizer uses three directive factors for controlling the movements of a pilot valve which in turn controls a compressed air cylinder operating a piston attached to the horizontal rudders. The controlling factors are: (*a*) the gyro which through the pilot valve operates the horizontal rudders against tendency to tip about the horizontal axis; (*b*) an anemometer which operates the pilot valve to volplane the machine in case the speed drops below the critical speed necessary for sustaining the plane; (*c*) a hand-setting device which permits the aviator to set the stabilizer for any inclination of climb or descent. The air platen further acts to adjust the throw of the levers, so that when running at slow speed a small tipping is counteracted by a suitable throw of the rudders. This is made necessary by the fact that the plane is more sensitive to inclinations of the rudders when running at high speed.

The lateral stabilizer serves as a directive factor acting on the pilot valve to control the movements of the ailerons so that they should operate to counteract against tipping laterally. When turning, the lateral stabilizer operates the control mechanism to bank the machine to an angle sufficient to prevent skidding. The gyros are driven by a three-phase alternating-current motor. The weight and dimensions of the various parts of the apparatus are as follows: the weight of the generator is about 25 lb., and it occupies a space about 6 in. by 6 in. by 10 in. The lateral stabilizer weighs about 18 lb. and is small enough to be conveniently disposed at the back of the aviator's seat. The longitudinal stabilizer weighs about 17 lb., and is placed below the aviator's seat in such a position that he can see its operation at all times. The author states that his apparatus has been thoroughly tested at San Diego, under the eye of Mr. Curtiss and the officers of the Aviation Corps of the United States Army. No precise data of tests are given in the article reported.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Vol. 21, no. 7, September 1913, Newcastle-upon-Tyne

SUMMER MEETING IN HOLLAND (p. 343, 15 pp. *d*). During this meeting several plants were visited, and their products inspected. It is reported that the present Kromhout heavy oil engines are of the two-cycle hot-bulb type. The fuel is fed from a float chamber to two pumps each of which has two delivery valves, and the speed of the engine is regulated by altering the length of the stroke of the pump. The governor is of the hit-and-miss type, but a knife-edge lifts the working striker out of engagement on the idle stroke thus reducing wear and tear. On the larger sizes of engines, starting is effected by pressure from a bottle filled with exhaust gas. The exhaust-receiver is water cooled.

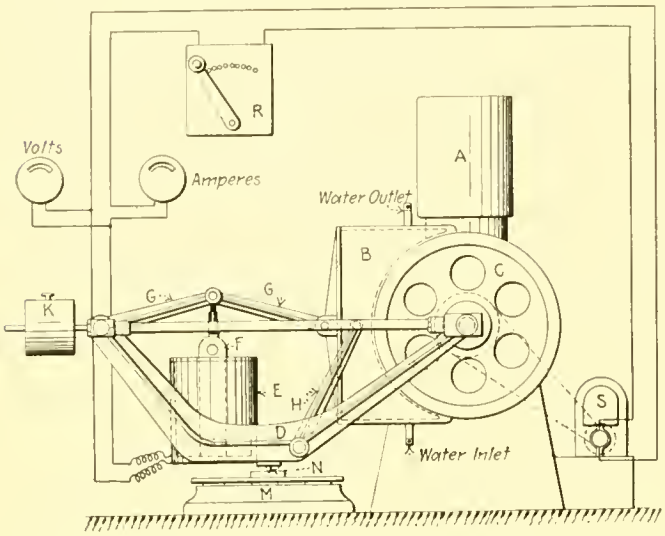


FIG. 17 JOHNSON ELECTRICALLY CONTROLLED DYNAMOMETER FOR TESTING GAS ENGINES

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS

Vol. 63, no. 6, July 1913, Newcastle-upon-Tyne.

Miners' Electric Safety Lamps
The Ochwadt Self-Registering Water Gage (Abstracted)
Messrs. F. Robson's & Company's Improve Air-Gage
The Davis-Biram Anemometer (Abstracted)

THE OCHWADT SELF-REGISTERING WATER GAGE (p. 240, 2pp., 2 figs. *d*). This is a gage designed to record continuously the pressure of ventilating current in coal mines, or the pressure or vacuum of air or gas in gas-plants and ironworks. The apparatus is formed with a base of two cylinders of equal width which merge into one large cylinder at the extreme base, and are filled with water up to a certain point. In each cylinder is a float, the two being joined together by a chain passing under a wheel in the single cylinder at the base, and fixed to one of the floats is a vertical rod to which the recording pen is attached. The recording chart is at the top of the apparatus, on a drum rotated about its vertical axis by a clock which may be so adjusted as to rotate the drum either once in 24 hours or once in seven days. The air is admitted through an inlet pipe into the cylinder opposite from that containing the float to which the writing device is attached.

THE DAVIS-BIRAM ANEMOMETER. For its description see *Coal Age*, November 1, 1913, p. 655.

SOCIETY OF AUTOMOBILE ENGINEERS

Vol. 5, no. 2, November 1913, New York

The Development of an Electric Tractor for Handling Freight Cars Over Tracks Laid on City Streets, T. V. Buckwalter
An Electrically Controlled Dynamometer for Testing Gas Engines, Nathan C. Johnson (Abstracted)
The Internal-Gear-Driven Truck Axle, Viggo V. Torbensen
A Correlation of the Magnetic and Physical Properties of Steel, Charles W. Burrows

AN ELECTRICALLY CONTROLLED DYNAMOMETER FOR TESTING GAS ENGINES, Nathan C. Johnson, introduction by R. D. Carpenter (4 pp., 3 figs. *d*). The electrically controlled dynamometer, consisting of a dynamometer with a field mounted on a cradle so that it can oscillate freely, is, in the opinion of Professor Carpenter, probably the most desirable of any dynamometer yet produced for the accurate measurement of developed power, but is expensive in use where a large number of units are to be tested. The device illustrated and described in the present article is an application of an electrical load-controlling device to a peculiar form of Prony brake, and is stated to have proved very satisfactory in practice.

The principle of operation of the device shown in Fig. 17 is exceedingly simple. A small magneto, or other generator having a straight line speed volts characteristic, is driven by a chain from the gas engine shaft. In circuit with the magneto is a rheostat *R* and a powerful iron-clad electromagnet *E*, which magnet is mounted on the frame composed of the side-pieces *D* having reach-rods joining in the bearings *J*, which bearings embrace the flywheel on either side. To the plunger *F* of the electromagnet are attached the two arms *G*, which form a toggle-joint acting on the hollow brake-shoe *B*, this shoe being water-cooled. The brake proper rests on a knife-edge *N* on the scale platform *M*; and a counterweight *K* on the back end of the toggle-joint serves to overcome the tendency of the brake-shoe *B* to fall inward against the wheel *C*. The thrust of the brake-shoe, due to the friction against the wheel, is taken up by the compression-arms *H* and communicated through the frame and knife-edge to the platform *M*. The turning moment, due to the friction of the bearings at *J*, is also indicated on the scale through the same point, so that there are no losses due to outside mechanism. Further, there are no strains on the engine shaft, because the thrust of the brake is taken up entirely by the bearings on either side of the flywheel.

The operation of the device is extremely simple. Briefly, the greater the speed of the engine, the greater the output in volts of the generator *S*; and the greater the voltage the greater the traction of the electromagnet *E*; and the greater the traction the more the thrust of the toggle-joint; with proportionate friction between the brake-shoe *B* and the wheel *C*. That is to say, the more speed the more volts, the more volts (by Ohm's law) the more amperes flowing in the electromagnet; and the more amperes the more friction; and the more friction the less speed. Therefore, by setting the rheostat *R* and the carbureter of the engine for any given load and speed, this brake will hold it constant for days at a time if necessary, the only limitation being apparently the efficiency of water-cooling of the brake-shoe. The power generated may be read off directly on a special scale-beam, or may be computed as with a Prony brake. The output of the generator *S*, as indicated on the voltmeter and ammeter, plus the known internal losses of the generator, must be

added to the brake readings to get the total power generated.

WESTERN SOCIETY OF ENGINEERS

Vol. 18, no. 8, October 1913, Chicago

The Decorative Possibilities of Concrete, C. W. Boynton and J. H. Libberton
Chicago Water Works, John Ericson (Abstracted)
Coöperation among Engineering Societies, Ralph D. Mershon

Vol. 18, no. 9, November 1913, Chicago

The Adaptation of Boiler Furnaces to Available Coals, Henry Kresinger and Walter T. Ray (Abstracted)
Chicago Subways
The Erection of the Municipal Bridge, St. Louis, W. H. Radcliffe

Chicago Water Works, John Ericson (36 pp., 17 figs. *dhs*). A partly historical description of the Chicago water works system.

The author discusses the question of metering the water delivered to customers, and shows that, while universal installation of meters is not advisable, if judiciously done, it will increase rather than diminish the city's revenues, irrespective of a decrease of pumpage. One of the important reasons why the existing plant is continually proving inadequate to meet the demand is the failure to adopt rational methods of water waste prevention. The fact that there is a large supply of water at the very door of the city does not mean that water should be considered as free as the air we breathe; it is shown that excessive pumpage does not benefit the people, and, in addition, when wasted, water escapes into the ground, and often becomes a detriment rather than a benefit.

In addition to the efforts for the conservation of the water delivered into the mains, a constant endeavor has been made to raise the efficiency of the plant. In this connection several interesting investigations had to be made. An accurate knowledge at frequent intervals of the amount of slip in the pumps was important, and for years, the records of pumpage had been based on plunger displacements and by estimate of the percentage of slip, if slip was considered at all. In order to obtain this information with reasonable accuracy, recording venturi meters were installed on the discharge mains of some new pumping engines, as well as many indicating and recording pitometers. In this way the condition of the pump valves of each engine is carefully checked at all times, and immediate repairs to or replacement of the same can be provided for when required. In another case considerable discrepancies appeared in the pressures reported from various pumping stations due to errors in pressure gages and elevations used in computing heads; for this reason a special design of mercury columns has been prepared, and will soon be installed in all pumping stations.

As regards the economy of operation of the pumping stations, a comparison was made between the Chicago plant and some private and municipally owned plants in other cities, on the following basis: The investigator determined the horsepower and the total amount of payroll of each pumping station, and from these deduced the number of horsepowers per dollar of daily payroll at each place (it is not stated on what basis the number of horsepower was obtained).

In the discussion which followed, objections to this basis of comparison were made since differences in the types, sizes and kinds of engines and operation under different conditions would lead to entirely dissimilar results. Henry A. Allen gave an insight into the conditions of operation at the Chicago pumping stations: in the city of Chicago at the present time, there are probably but three engines provided with suitable safety governors that, in the case of the bursting of a water main or of other cause tending suddenly to reduce the water pressure at the pumps, would stop the engines automatically and prevent them running away and going through the roof. As a matter of safety, more oilers are carried than would be the case were all engines of modern design and properly equipped; should anything happen, the oiler must be ready to jump to the throttle.

The Adaptation of Boiler Furnaces to Available Coals, Henry Kresinger and Walter T. Ray (60 pp., 17 figs. *epat*). The authors, in their work as fuel engineers of the Clinchfield Fuel Company, have been brought face to face with the fact that in certain districts of the South, owing to prevailing rates, only certain kinds of coal, mainly those with a highly volatile content, could be used, and the existing boilers did not appear to be fully adapted economically to take care of them.

The authors have therefore made an extensive series of tests in order to determine for water tube boilers (with tubes inclined slightly from the horizontal, having transverse gas baffles such as make the gases cross the tubes up, down, and up (three passes) whether by baffling the boiler horizontally and thereby obtaining a larger combustion space in the furnace, high volatile coal can be burned with good results; and whether, with the horizontal baffle, Pocahontas coal can be burned as economically as with the standard vertical baffle.

These tests were made in three series: The first series consisted of seven tests, and was made with the boiler baffled vertically, as it was installed by the maker (Fig. 18 A). The second series, also of seven tests, was made with the same boiler baffled horizontally in a way such that the space beyond the bridge wall was used as a combustion chamber, the burning gases passing lengthwise, first under the boiler, and then twice among the tubes, and out through the breeching. The third series, consisting of five tests, was made with the same boiler baffled horizontally in a way such that the gases passed lengthwise under the boiler as in the second series, then three times among the tubes, and finally under the steam drums and out through the breeching. All of the tests were run under the actual operating conditions. From a table giving the summary of results of his tests the author draws the following conclusions: Much better results can be obtained with Clinchfield coal when the boiler is baffled horizontally; there is also a marked improvement in the results in favor of the horizontal baffling when Pocahontas coal is used as fuel. The horizontal three-pass baffling gives the highest evaporation; the horizontal two-pass baffling gives the highest horsepower developed during the tests. With the two-pass horizontal baffling better evaporation and higher horsepower can be obtained with Clinchfield than with Pocahontas coal and the standard vertical baffling. The following additional remarks are of interest:

The boiler was run considerably above its rated capacity all the time. During regular operation the boilers would probably be operated most of the time below it, and would show a higher efficiency than that shown by the test. With

the present standard baffling of the boilers the greatest heat loss is in the chimney gases. During the last series of tests the author measured with an anemometer the velocity of air entering the ashpits of this boiler and also of boiler No. 1 which was equipped with the standard vertical baffles. It was found that on this boiler the velocity was about 450 ft. per min. On the other boiler it was about 800 ft. per min., or nearly twice as much, although only about two-thirds as

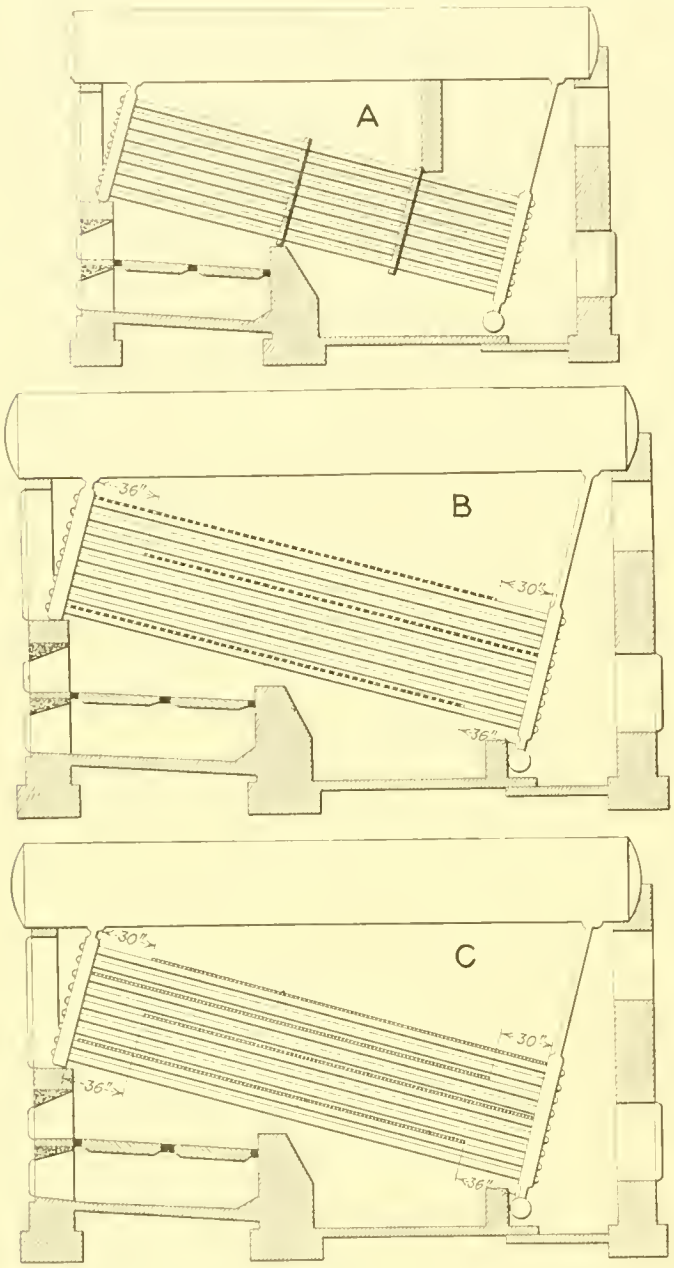


Fig. 18 Watertube Boilers with Various Types of Baffling

much coal was burned with the standard boiler as with the three-pass boiler. This velocity measurement showed conclusively that entirely too much air was used with the standard boiler. The area of the ashpit doors on both ashpits was the same. The approximate cost of materials for baffling with two horizontal passes is stated to be $57.25, and with three horizontal passes, $70.65.

In the discussion which followed, George H. Cushing, Mem.Am.Soc.M.E., called attention to the fact that the distribution of coal has so far been fixed by the freight rate charged the transit limit of the coal; hence the zone in which it would be sold has been pre-determined by transportation considerations, which are entirely outside both the coal and manufacturing industries. The mere fact of rearranging the coal-burning apparatus to suit the available fuel removes the railroad as the dominating influence, and substitutes for it engineering, which is far more an exact science than the rule-of-thumb now governing the rate-making function. For the coal industry, the adaptation of the boiler to the fuel used is of great importance because it will increase the demand for an exactly sized product, and that means introducing a manufacturing process for the purpose of giving to the consumer precisely the size and kind of coal he wants. That means also advancing the price, which is of less importance to the consumer after he learns to get full benefit of the exact sizing. For the boiler manufacturer to make a standard furnace and boiler setting is of course a very simple proposition; but the time has come when he will be forced to determine his factory problems mainly by consideration of how the buyers of his equipment can get power cheap. To do this, he will have to produce a flexible boiler-furnace setting that will give a proper mixture of coal gas and air while using any kind of coal, and if he does so he may add to the selling price of his iron and brick the price of high-class engineering service.

E. R. Fish gave a brief history of the Heine boiler in this country. The first Heine boiler was built in this country in 1882 by Col. E. D. Meier, Past-President of the Society, and to him is due the credit of having been the first to promote commercially the horizontal type of baffling.

T. A. Marsh, Mem.Am.Soc.M.E., pointed out how in the last five or six years the height from the header to the floor has gradually increased. In 1908, with a setting similar to that of Fig. A, a boiler was ordinarily set 7 ft. 6 in. from the header to the floor; and with proper draft, a sufficiently long arch, and furnace roof, a certain amount of smokelessness was obtained. The next year 8 ft. of height was considered to be necessary, and later on 8 ft. 6 in.; but 9 ft. was opposed both by the purchasers of the boilers and installers of equipment. Today a very good reason for installing boilers with less than 9 ft. 6 in. under the header has to be shown; and one of the large firms in the East has laid down the fixed rule that no Babcock and Wilcox type of boiler that they install shall be set with less than 12 ft. under the header; they are obtaining excellent results. Furnaces so designed are vertical, while those with tiled roofs are horizontal.

In the practice of the speaker, puddling of outside walls happened two or three times, and in order to avoid this kind of accidents, it is necessary that the lining in the two-pass boiler in the combustion chamber should be No. 1 fire brick.

E. A. Fessenden, Jun.Am.Soc.M.E., presented a table showing some points of comparison between the different methods of baffling employed in the tests. The draft loss through the boiler passages is less for the horizontal two-pass baffling than for the original baffling. The number of complete reversals of the gas stream is the same for the two cases, but two-pass horizontal baffling offers less resistance between the points of reversal. The resistance of the horizontal three-pass baffling is slightly greater than that with the original baffling.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

Joseph Harrington addressed the Armour Student Branch on December 3, 1913, taking as his subject The Practical Application of the Theory of Furnace Efficiency. He dwelt in detail on each phase that makes for maximum efficiency, and touched on many points of interest to those present.

COLUMBIA UNIVERSITY

On December 5, W. T. Price, Jun.Am.Soc.M.E., gave an illustrated lecture on The Development of the Oil Engine in the United States before the Student Branch at Columbia University. He treated the design of large and small engines, and showed why some of the very successful small engines could not be built in large sizes. He discussed also the Diesel engine, widely used in Europe and comparatively new in this country. He closed with comparative figures upon the cost of purchased electric power and that obtained with the oil engine, which comparison favored the latter.

CORNELL UNIVERSITY

At a meeting of the Sibley College Student Branch held December 8, Col. E. D. Meier told briefly of some of the incidents of the trip to Germany made by the Society last summer. He spoke also of the most recent developments of the Diesel engine, particularly as used in locomotives. He said arrangements were being perfected to have a Diesel engined ship open for inspection in New York very shortly. The next day he spoke to about two hundred members of the senior class, repeating some of his talk of the previous evening, adding a discussion of the ethics of the engineering profession.

PENNSYLVANIA STATE COLLEGE

The Pennsylvania State College Student Branch held its regular monthly meeting on November 19. The program consisted of talks by H. G. Hall on Boiler Scale and the Appliances for removing it from Boiler Tubes; and A. L. Foell on Concrete, constituting the results of tests conducted at the Massachusetts Institute of Technology.

PURDUE UNIVERSITY

On November 25, Gilbert A. Young, Mem.Am.Soc.M.E., addressed a joint meeting of the LaFayette-Indianapolis Branch of the American Institute of Electrical Engineers and the Purdue University Student Section of this Society, choosing for his subject A Comparison of Engineering in Germany and America. In reality his talk was an account of his trip abroad last summer with the Society; he told of the voyage across, visits to the various universities and his impressions of German engineers and engineering.

The December 9th meeting was addressed by A. R. Nothingham, instructor in thermodynamics, who discussed his work with Professors Carpenter and Thomas, both Members of the Society, in the determination of C_p for superheated steam. He compared the elaborate apparatus used at Cornell University with that used by Knoblauch and Jacobi in Germany, and described the difficulty of drying the steam thoroughly. He described further the tests made to determine the cooling curves of superheated steam.

STATE UNIVERSITY OF IOWA

At a meeting held on December 2 of the State University of Iowa Student Branch, F. A. Richards gave a talk on the Locomobile. The main facts and data referred to were obtained from several of the recent engineering periodicals and included a description of the locomobile, its history, development and efficiency. A comparison of the amount of coal used in the locomobile per indicated horsepower with the amount used in the ordinary power plants of today concluded the lecture.

STATE UNIVERSITY OF KENTUCKY

G. B. Wurst, local forecaster for the United States Weather Bureau Department, addressed the Student Branch of the State University of Kentucky on November 13. In his introduction Mr. Wurst pointed out clearly and forcibly the advantages an engineer possessed who had a knowledge of the causes and effects of weather conditions. After a brief description of the apparatus for obtaining weather data and the principles underlying the laying out of weather maps, the members were invited to inspect the various instruments and to note especially the accuracy required in their construction. The electrical recording devices were found to be of particular interest.

STEVENS INSTITUTE OF TECHNOLOGY

The entire student body and many of the faculty attended the meeting of the Stevens Engineering Society held November 25. Calvin W. Rice, Secretary of the Society, told of the reception the Society had while in Germany last summer as the guest of the Verein deutscher Ingenieure. The speaker of the evening, Miller Reese Hutchinson, Mem.Am.Soc.M.E., was then introduced by Alex. C. Humphreys, Past-President of the Society, and he chose for his topic the Products of the Edison Laboratory.

SYRACUSE UNIVERSITY

The Syracuse University Student Branch has adopted the policy of having each member of the society prepare a short paper on some topic with which he is familiar, and inaugurated the plan at its meeting of December 5, when C. C. Keesler gave a paper on Efficiency as Applied to Shop Methods. He discussed three methods of obtaining this efficiency and in conclusion gave a brief summary of the methods employed by Mr. Taylor along these lines.

UNIVERSITY OF CALIFORNIA

A meeting of the University of California Student Branch was held December 2 and three papers were read as follows: Manufacture of Gas from Petroleum as practised in California, W. W. Penniman; Manufacture of Water Gas as practised in New York, R. S. Tom; High-Pressure Fire System of San Francisco, C. A. Rosen.

UNIVERSITY OF KANSAS

The University of Kansas Student Branch held a meeting on December 4. The papers were on the subjects of The Los Angeles Water Supply Aqueduct, by W. J. Malcolmson; and the Use of Nitrogen-Filled Incandescent Lights, by John Hartman.

UNIVERSITY OF MAINE

F. B. Slocum of the Continental Iron Works, Brooklyn, N. Y., spoke before the University of Maine Student Branch, November 25, on Internal Furnace Boilers. The author treated the development of this type of boiler and enumerated its advantages over the externally fired boiler; he gave also a detailed account of the Morrison Suspension Furnace. In part he said the internally fired boiler was used altogether on shipboard and was becoming recognized as better than externally fired boilers on land, owing to the fact that a brick setting was not required. These settings were a source of much trouble because cracks formed in them which allowed air leakage and the results were therefore inefficient. In 30,000 internally fired boilers in use in this country there was not a single record of a fatal explosion. This was due largely to the fact that the flames did not come in direct contact with the boiler shell. The firebox and ashpit were entirely surrounded by water, thus preventing the furnace from burning out. The Morrison Suspension Furnace was developed for internal furnace boilers especially. It was built of corrugated steel set into the boiler. Such a furnace was stronger than a plain one, and had an added advantage:

as the water heated, the top of the furnace expanded and contracted, and any scale that might be formed was loosened and removed by the movement of the water in the boiler.

Mr. Slocum also spoke of the construction in the Continental works of the famous *Monitor* and many other "ironclads."

UNIVERSITY OF MISSOURI

The University of Missouri Student Branch held a meeting on November 17 and Sidney Levy was the speaker of the evening. His talk was on Some of the Good and Bad Points of the Present Automobile.

UNIVERSITY OF NEBRASKA

Prof. H. H. Norris of Cornell University spoke before a special meeting of the University of Nebraska Student Branch, December 2, on the subject of Prime Movers. His talk was intensely interesting to those present for he described several of the large installations in the East which he had personally witnessed.

UNIVERSITY OF WISCONSIN

On December 4, the University of Wisconsin Student Branch held a meeting when C. D. Sperry gave a talk on a New Type of Car to be driven by Magnetic Propulsion. The car was designed to replace the carriages used in pneumatic tubes. L. V. Cowin outlined the development of different types of speedometers and tachometers now being manufactured.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

1120 Mechanical engineer, who has had practical experience in power plant work and construction, to take charge of approving and checking field drawings for the installation of Taylor stokers. Salary to start $1500 to $1800.

1203 Thorough mechanic familiar with both alternating and direct-current practice, capable of taking responsible charge of the repair shops, water and steam power equipment, of a large textile plant situated in Connecticut. Position would be that of assistant to the master mechanic, and to the right man would eventually lead to position of master mechanic. State age, experience, references and compensation expected. Apply through the Society.

1206 A man with some manufacturing experience and familiar with sales work, to take charge of an office in a manufacturing concern just outside of New York City. Possibilities good and position offers an excellent opportunity to the right man. Desire technically trained man about 30 to 35 years of age.

1209 Company building line of high-grade centrifugal pumps is about to open sales agencies on a commission basis in principal cities of the United States and Canada. Communications invited from sales engineers who are open for such a proposition. Apply through the Society.

1220 Cost man for an electrical apparatus manufacturing company in Albany; should have at least three or four years' experience in cost work.

1221 Cost man for moving picture machine concern in New York; prefer man with two or three years' experience in cost work.

1223 Member holding patents on dispensing device and carbonating machine, desires to come in contact with manufacturing concern that will place these patents on the market; the inventions are original and highly thought of by engineers. Apply through the Society.

1224 Two draftsmen, design of construction dump cars. Salary $15 to $18 a week.

1225 One or two draftsmen wanted; experienced men not filled with inventive ideas but capable of serving as "gang bosses" in drafting room. Experience in engine work, particularly internal combustion engines. Apply through the Society.

MEN AVAILABLE

1 Member; age 35; technical graduate; successful record of 13 years as engineer and manager; has had entire charge of design and construction of large industrial plants, and reorganization. Good manager and systematizer; wants position near New York. Can show record of work done.

2 Junior Member; age 25; graduate mechanical engineer, experienced as factory inspector; desires position with chance for advancement; can give best of references; at present employed.

3 Member; mechanical engineer; graduate Massachusetts Institute of Technology; now holding position as engineer and factory manager, desires change to position of greater opportunities; 14 years' experience in automobile industry, successfully holding positions as designing engineer on pleasure cars and trucks, and various factory positions up to and including factory manager, employing 1800 men; good executive, with ability to reduce cost in design and manufacture.

4 Member; mechanical engineer of large experience on various machinery and machine tools; would like to make arrangement with reputable concern as engineering or sales representative; 20 years' practical experience, salesman, shop, designer, and engineer.

5 Member; position as works manager or general superintendent; experienced in manufacturing shoe machinery, typewriters, firearms, and automobiles; familiar with the latest methods of scientific management and fully competent to organize all departments where increased production at a reduced cost is the chief object.

6 Junior Member; age 34; technical graduate; 15 years' experience as machinist, draftsman, erecting and operating engineer with firms building and operating gas, steam-engines, and pumping machinery; desires position in shop or drawing room.

7 Junior Member; graduate Ohio State University; five years' experience with large firms in design, erection, and operation of steam-power plants; experienced in design of structural work and refrigeration; desires permanent connection with firm making a specialty of design and construction of industrial plants; age 28; married.

8 Member since 1882; graduate of the machine shop and engine room and up to $6000 salary; 15 years' experience as engineer and sales office manager; thoroughly informed on steam prime movers and steam appliances. Getting too old for construction work and great responsibility and would like position in sales office in New York City where services can be used to advantage.

9 Member; desires position as works manager, superintendent, or engineer; competent to organize all departments of manufacturing plant along modern lines; expert on developing new inventions; long experience; best references.

10 Member; mechanical engineer; at present engaged; desires position as manager, superintendent, or special organizer. Thoroughly practical mechanic with good technical education; good executive, organizer, and production or industrial engineer; splendid experience with good results; thoroughly conversant with and experienced in best principles and methods of efficient management; good common sense; good judgment.

11 Graduate mechanical engineer, age 27, married; three years' experience with large construction firm, three years' experience in mechanical and engineering departments of

large industrial plant. Desires to locate in East. At present employed.

12 Technical mechanical engineer; 13 years' experience operating large plants, advertising manager, sales engineer, assistant manager and general manager of large companies engaged in engineering work; would like New York agency for progressive company with well paying mechanical line; or developing, manufacturing and selling meritorious mechanical line; or would consider taking an interest in an existing firm or forming a new firm of either consulting or contracting engineers.

13 Member; consulting engineer; desires the representation of first-class firms for the District of Columbia.

14 Member; graduate mechanical engineer with wide experience in gas and oil engine design, thoroughly acquainted with latest practice, is prepared to introduce complete line of Diesel oil engines of proven merit, which can be manufactured at a low cost. Applicant desires to make connection, preferably on a partnership basis, with responsible manufacturing concern or party willing to take up manufacture of oil engines on broad business policies.

15 Member; age 42; desires position as assistant manager or general superintendent; practical mechanic; wide experience in office, stores, and shop in the manufacture of internal-combustion engines, stationary and tractor, marine engines, pumps, mining machinery, steam and locomotive work, electrical apparatus; design and erection shop and foundry buildings, steam, electric, pneumatic and hydraulic power plants. Competent to assume full charge.

16 Member; mechanical engineer; having duties calling him to Paris, will assume additional duties of an engineering or commercial nature for any one wishing to avail themselves of the services of a representative in France during February and March.

17 Associate-Member; graduate mechanical engineering from Cornell, having seven years' experience in the design, construction, operation, and testing of large steam power stations, desires position that offers a promising future. At present employed.

18 Member; technical graduate, 31 years of age, desires position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing, purchasing, superintending construction and operating departments; consulting engineering work on large properties; power production investigations; cost reduction; experienced in mill and reinforced concrete construction work; at present employed and desires a change for advancement.

19 Mechanical engineer, technical graduate, married, desires a position as master mechanic's assistant; experienced in design, installation, inspection, repair, and other general mechanical work with a very large industrial concern; a good executive and manager of men; at present employed, but desires similar position with better opportunities. Location immaterial.

20 Associate member; age 39; technical graduate of high grade institution, wishes executive or administrative position of responsibility; now employed in charge of construction work; wide practical experience has included mechanical and electrical shop work, drafting, and design. Responsible charge of various classes of construction work in concrete, steel, brick, etc., correspondence, reports, purchasing, etc.

21 Member; wishes to connect with some reliable firm with a high standing, where the services of a high grade executive and engineer are needed to increase production by systematizing general shop practice and the design of up to date tools, etc. A practical and technical man well versed in interchangeable manufacturing, including die casting practice and automatic machinery of every description.

22 Chief-engineer, works manager, designer, wide experience in iron works, charge of production development and standardization of manufacturing; methods and efficiency systems; supervision of testing from raw material to complete machinery; mechanical and electrical operation of plants; specialty hoisting machinery.

23 Graduate Stevens '97, member of Society; broad experience including machine shop practice, superintendence of construction, field work, tests of prime movers, boilers, and power house design. For many years connected with leading consulting engineers and contractors in New York City as designing engineer and draftsman. Desires position of similar nature with engineering firm.

24 Member, wide experience in various responsible capacities, wants position as assistant to works manager where it is desired that the applicant must be a practical mechanical engineer with general experience in shop and mill practice, and capable of successfully designing special machines for own use or standard machines for regular line of competitive manufacture. Capable of supervising and responsible for the work of the engineering, cost and production departments. At present employed, married, salary $250 per month. Any location.

25 Junior member, age 26, five years experience in designing of automatic machinery, desires a position as assistant to consulting engineer, with view of taking interest in business in about a year's time; exceptional record, would prefer to locate in the east. At present employed.

26 Metallurgical engineer, 29 years of age, broad experience designing and superintending the erection of mill buildings, furnaces and machinery. Salary $2,500.

27 Member, experienced as general or business manager, salesman and executive, desires position with manufacturing concern or branch house, has tact and business ability with many years experience as sales engineer. Broad acquaintance in the engineering, contracting and manufacturing field.

28 Member, with established office in New York City wants to represent reliable manufacturing concern.

29 Stevens graduate, practical minded and ambitious, age 29, with eight years office and field experience, desires position of trust with a future.

30 Electrical and mechanical engineer and designer desires position as assistant to chief engineer or position with similar responsibility; age 27 years; of good technical education and seven years practical experience.

31 Sales engineer, experienced in handling high-grade specialties in power transmission and machinery lines; known to machinery and supply trade of United States and Canada for past eight years.

33 Commercial engineer has had responsible charge of sales and erection of suction gas producers, engines and power pumps, competent as office executive, and in publicity and purchasing work.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

American Institute of Consulting Engineers. The Status and Professional Relations of the Engineer. *New York.* Gift of the institute.

L'Anatomie de la Voiture Automobile, F. Carlès. *Paris, 1913.*

Carburation in Theory and Practice, R. W. A. Brewer. *London, 1913.*

Design of Surface Combustion Appliances, C. E. Lucke. Gift of the author.

Detroit (Mich.) Board of Water Commissioners. Sixty-first annual report, 1913. *Detroit, 1913.* Gift of the board.

Diesel Engine Pumping Station at the Gladstone Dock,

LIVERPOOL. Reprinted from *Engineering*, 1913. Gift of W. R. Hayne.

DER DIESELMYTHUS, T. Lüders. *Berlin, 1913.* Gift of M. Krayn.

FARM GAS ENGINES. C. F. Hirshfeld and T. C. Ulbricht. *New York, 1913.*

GUIDE TO SANITARY INSPECTIONS, W. P. Gerhard. *New York, 1909.*

HANDBOOK FOR MACHINE DESIGNERS AND DRAFTSMEN, F. A. Halsey. *New York, 1913.*

HIGHWAY ENGINEERING, TEXTBOOK ON, A. H. Blanchard and H. B. Drowne. *New York, 1913.*

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION. Report of proceedings of the ninth annual convention, 1913. *Winona, Minn., 1913.* Gift of the association.

MECHANICAL REFRIGERATION. A treatise for technical students and engineers, H. J. Macintire. *New York, J. Wiley & Sons, 1914.*

Professor Macintire, Mem.Am.Soc.M.E., is in the University of Washington faculty. The work is the most complete American publication on the subject, and includes chapters on testing, applications and economics. In the appendix are model specifications and many useful tables.

MODERN BATHS AND BATH HOUSES, W. P. Gerhard. *New York, 1908.*

DAS MOTORBOOT UND SEINE MASCHINELLE EINRICHTUNG, H. Haeder. *Weisbaden, 1913.*

NATIONAL CONSERVATION CONGRESS. Addresses and Proceedings, 1st, 2d, 4th, 1909, 1910, 1912. Gift of Calvin W. Rice.

NEW ENGINEERING BUILDINGS AT MINNESOTA, F. C. Shenehon. Gift of University of Minnesota.

NEW JERSEY. BOARD OF PUBLIC UTILITY COMMISSIONERS. Reports, vol. 1, May 1911-June 1913. *Trenton, 1913.* Gift of Charles A. Mead.

OLD-TIME TELEGRAPHERS AND HISTORICAL ASSOCIATION. Thirty-second annual reunion, 1913. Gift of the association.

PHILADELPHIA. TRANSIT COMMISSIONER. Report, vols. 1-2, July 1913. Gift of Ford, Bacon & Davis.

QUEENSLAND. ENGINEER FOR HARBORS AND RIVERS. Report for the year ended June 30, 1913. *Brisbane, 1913.* Gift of Department of Harbors and Rivers.

RAILROAD AND ENGINEERING JOURNAL. vol. 64-66. *New York, 1890-1892.*

REINFORCED CONCRETE, A. W. Buel and C. S. Hill. ed. 2. *New York, 1906.*

SAFEGUARDS FOR THE PREVENTION OF INDUSTRIAL ACCIDENTS. Edited by David Van Schaack. ed. 2. *Hartford, Aetna Life Insurance Co., 1913.*

SANITATION, WATER SUPPLY AND SEWAGE DISPOSAL OF COUNTRY HOUSES, W. P. Gerhard. *New York, 1909.*

SANITATION OF PUBLIC BUILDINGS, W. P. Gerhard. *New York, 1907.*

SOCIETY OF AUTOMOBILE ENGINEERS. Trans., vol. 7, pt. 2; vol. 8, pt. 1. *New York, 1912-1913.* Gift of the society.

STATIONARY ENGINEERS' BOOK, 1910-1911. Compiled by C. F. Owen. *Milwaukee, Wisconsin, Directory Co.*

SUBMARINE ENGINEERING OF TO-DAY, C. W. Domville-Fife. *London, 1914.*

TEXTBOOK ON TRADE WASTE WATERS: THEIR NATURE AND DISPOSAL, H. M. Wilson and H. T. Calvert. *London, 1913.*

THEATRE FIRES AND PANICS: THEIR CAUSES AND PREVENTION, W. P. Gerhard. *New York, 1896.*

TRAVELING ENGINEERS' ASSOCIATION. Proceedings of twenty-first annual convention, 1912. *Buffalo, 1913.* Gift of the association.

UTAH CONSERVATION COMMISSION. First biennial report, 1913. *Salt Lake City, 1913.* Gift of the commission.

PLANE AND SOLID GEOMETRY, W. B. Ford and Charles Ammerman. Edited by E. R. Hedrick. *New York, 1913.*

An elementary textbook for school use. It is based on the recommendations of the Committee of Fifteen of the National Education Association, 1911.

VECTORIAL MECHANICS, L. Silberstein. *London, Macmillan & Co., 1913.*

A well written little volume presenting the chief principles and theorems of theoretical mechanics in the language of vectors. After discussing certain special principles, such as the principles of vis-viva, of center of gravity, which the author considers synonymous with that of center of mass, and the principle of areas, the author passes to the consideration of rigid dynamics, mechanics of deformable bodies and hydrodynamics. Certain parts, for example, that referring to the treatment of the Nabla, are particularly well written, and the book in general will be useful to those who wish to become acquainted with this new method of mathematical analysis without having much time to devote to it. Whether vectorial analysis is of material importance to the mechanical engineer is as yet a question. Lord Kelvin, in the sixties, refused to admit quaternions into the Treatise on Natural Philosophy unless P. G. Tait, who insisted on doing so, would show him that there is one theorem of mechanics that could be solved by vectors better than by classical mathematical methods. Since then vectorial analysis has rendered valuable services in several branches of engineering, e.g., in alternating currents, but, as far as mechanical engineering is concerned, the present work is interesting in that it does not contain a single proposition that could not be proved by Cartesian methods. L. G.

WATER SUPPLY, SEWERAGE AND PLUMBING OF MODERN CITY BUILDINGS, W. P. Gerhard. *New York, 1910.*

WENTWORTH INSTITUTE. Catalogue, 1913-14. *Boston, 1913.*

EXCHANGES

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CANADIAN SOCIETY OF CIVIL ENGINEERS. Charter, By-Laws and List of Members, 1913. *Montreal, 1913.*

INSTITUTION OF MECHANICAL ENGINEERS. Proc., 1913, pts. 1-2. *London, 1913.*

TRADE CATALOGUES

BOSTWICK STEEL LATH CO., *Niles, Ohio.* "Stucco" on truss loop metal lath, 15 pp.

BRISTOL CO., *Waterbury, Conn.* Cat. 1400, electric pyrometers, September 1913.

ELECTRIC TACHOMETER CO., *Philadelphia, Pa.* Bull. 100, Hopkins electric tachometers, April 1913.

HENDEE MFG. CO., *Springfield, Mass.* Indian motorcycles, 1914, 28 pp.

LENT MOTOR FIRE ENGINE CORPORATION, *New York.* Automobile fire engines, how the demand therefor is met, 8 pp.

LUNKENHEIMER CO., *Cincinnati, Ohio.* Regrinding valves, 23 pp.

NORTH WESTERN EXPANDED METAL CO., *Chicago, Ill.* Expanded metal construction, November 1913.

SANGAMO ELECTRIC CO., *Springfield, Ill.* Bull. no. 36, ampere-hour meters for general service, October 1913.

SYKES METAL LATH AND ROOFING CO., *Niles, Ohio.* Sykes expanded cup lath.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity magazine, November 1913.

VULCAN CRUCIBLE STEEL CO., *Aliquippa, Pa.* Cat. no. 5, manufacture of high-grade crucible tool and special steel.

UNITED ENGINEERING SOCIETY

ADDRESS BY JUDGE JOHN A. STOUGHTON BEFORE THE NAVY LEAGUE, U. S. Convention, at Hotel Willard, Washington, D. C., February 22, 1912. Gift of W. J. Andrews.

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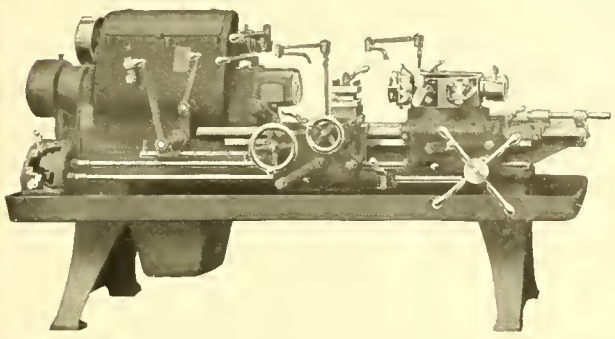

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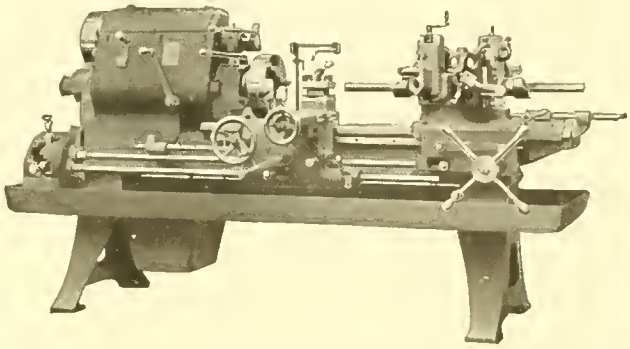

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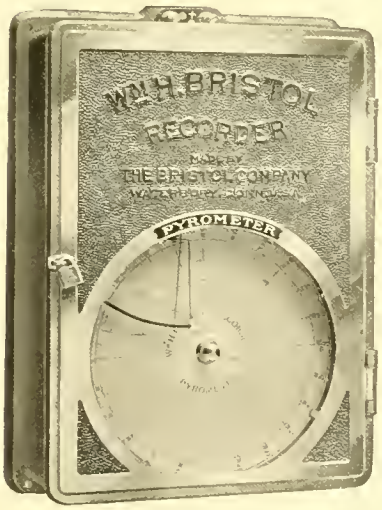

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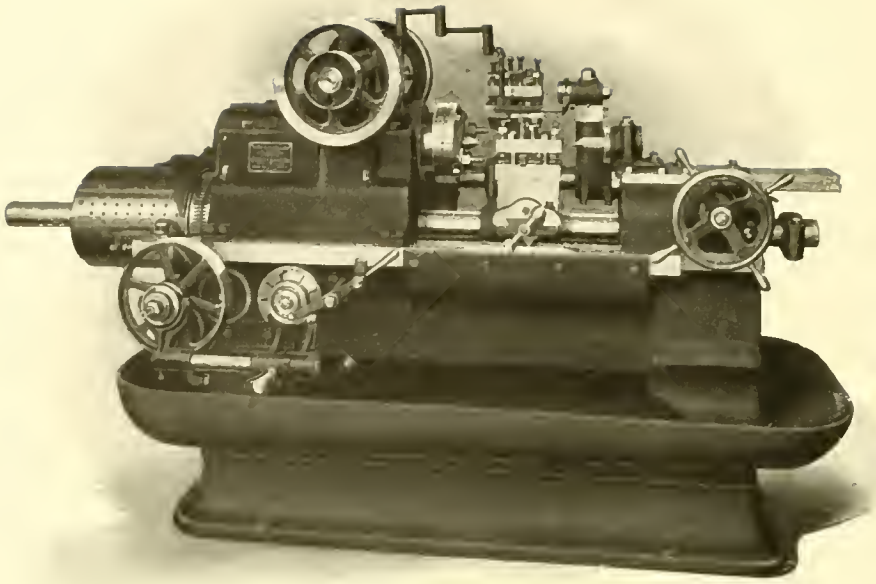

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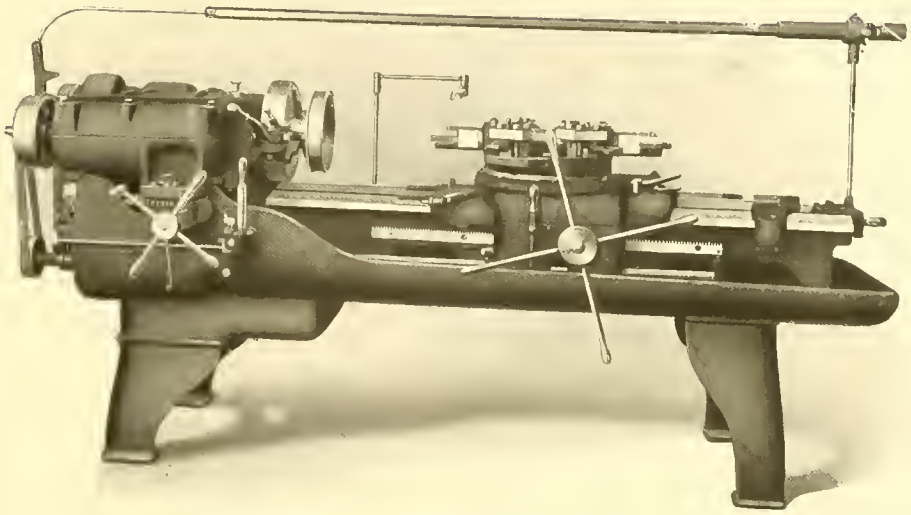

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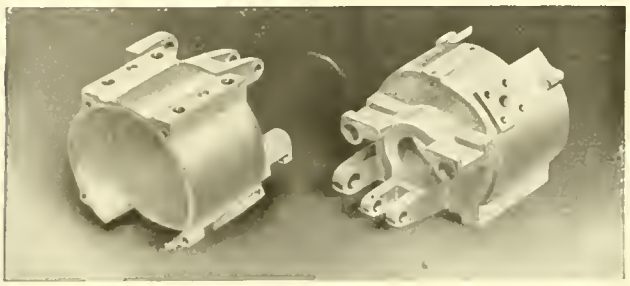
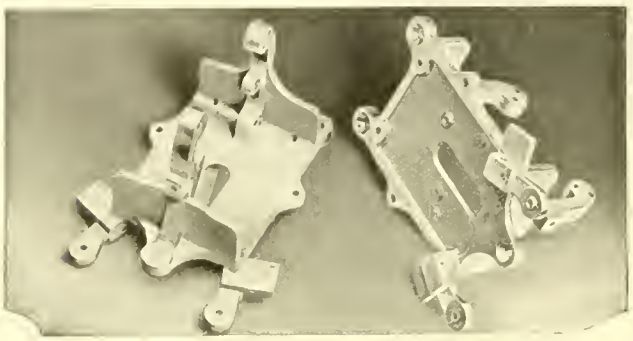
Die Castings in Aluminum and White Metal Alloys



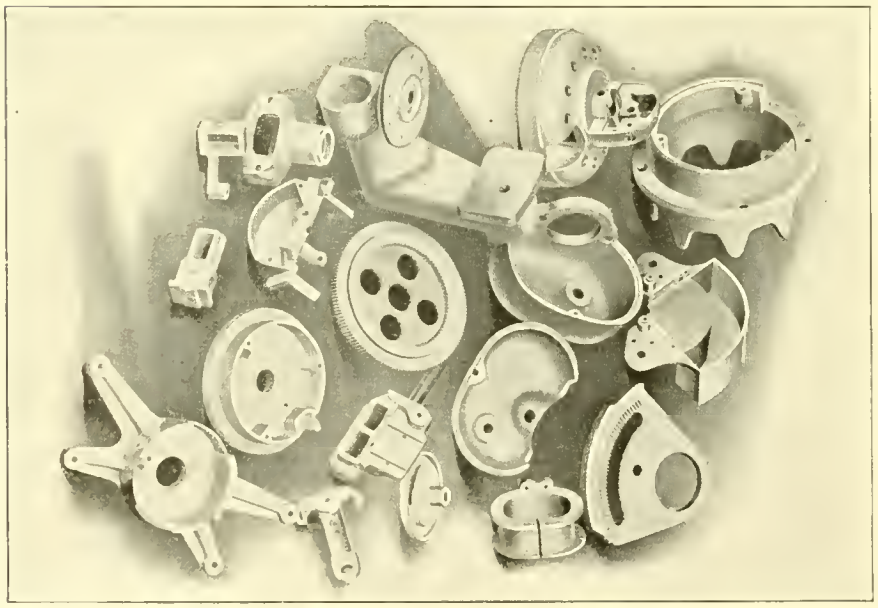


Die casting is the logical method for quantity production of simple or intricate small parts not subjected to great strain.

The dollars-and-cents saving over machining and finishing of sand-cast parts is a big economy factor and the die castings made by us are accurate within .0005 inch on the smallest to .003 inch on the largest pieces.

By availing yourself of our skilled die makers, up-to-date equipment and extensive facilities you can profitably avoid the uncertainties, inaccuracies, burden, and expense of an individual machine shop. You thus relieve yourself of possible labor troubles, of cost of machines, power, light and depreciation, and you can utilize machine shop space to better advantage.

Die castings from our plant are dependable for strength, accuracy and general usefulness, and in designing the dies, we get details right *the first time.* Efficiency and reliability are never sacrificed in our plant.



Die castings made in aluminum by our process are decidedly superior in strength, finish, accuracy and reliability. The quick chilling in the dies greatly increases the tensile strength. No machining is necessary except where very close dimensions are required.

We also make babbitt-lined bronze bearings for high speed and high duty service.

Advice and quotations on prospective work and samples of similar work will be sent upon request.

DOEHLER DIE-CASTING CO.

COURT & NINTH STS. BROOKLYN, N.Y.

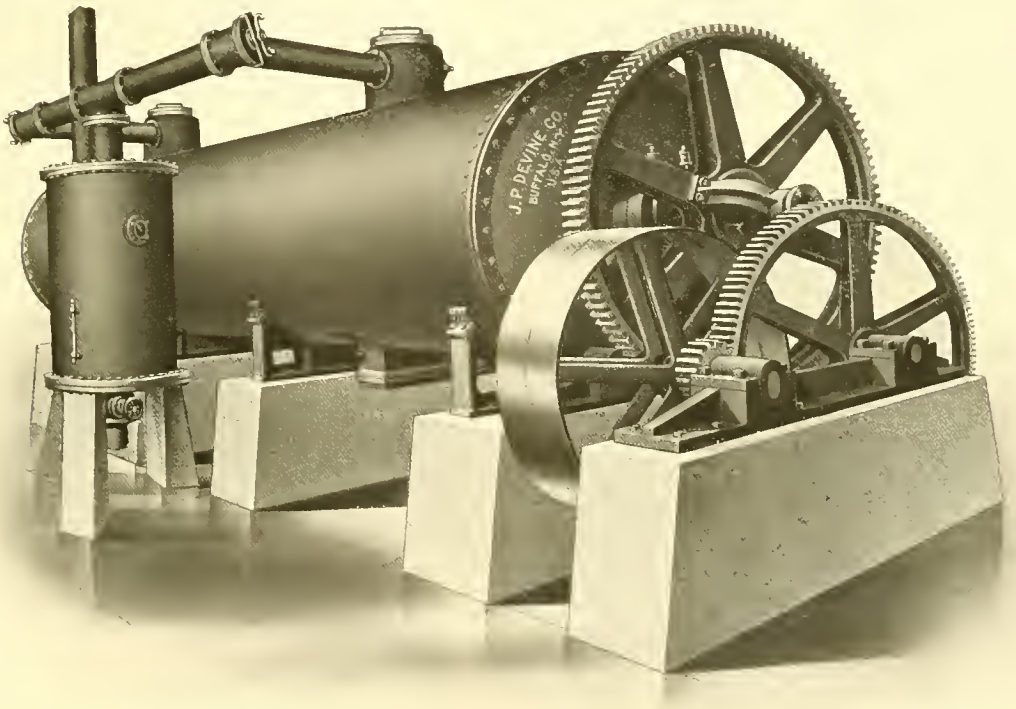
(1)

Drying Problems May Confront You

Our

Vacuum Drying Apparatus

removes moisture, at lowest temperature, rapidly, thoroughly, uniformly, economically. Thirty years of experience in this one field of activity cannot help but be of value to you.



The thousands of installations in daily operation and the many repeat orders are the best evidence of our claims to be of service.

J. P. DEVINE CO.

1372 Clinton Street **Buffalo, N. Y.**

Cocheco Belting

The Belt That Lasts on Hard Drives

Cocheco Belting is made from the best grade of packer steer hides tanned by the long, old-fashioned white oak bark process. We curry the leather by a special process—developed in our seventy-odd years' experience, which gives a firm, pliable stock.

Every step in the manufacture is carefully watched and inspected. Every man is held strictly accountable for his own share of the work. Thus every handling insures a rigid and thorough inspection, which is one of the reasons why Cocheco Belting is as far in advance of the field today as when it first won its quality reputation 72 years ago.

Shedite Waterproof Belting is made of the same high-grade backbone stock as Cocheco and is guaranteed to be absolutely waterproof and steamproof and to withstand sudden changes of temperature.

Let us show you why Shedite and Cocheco Belting are unequalled and how they are made. Write for descriptive matter.

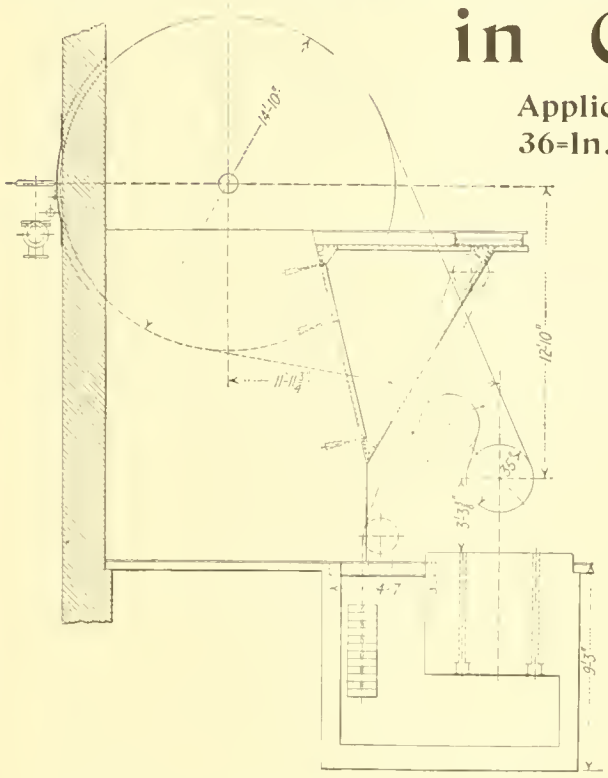
I. B. Williams & Sons

DOVER, N. H.

72 Murray St.,	-	-	New York
14 N. Franklin St.,	-	-	Chicago
157 Summer St.,	-	-	Boston

Belt Transmission of 740 hp. in Close Quarters

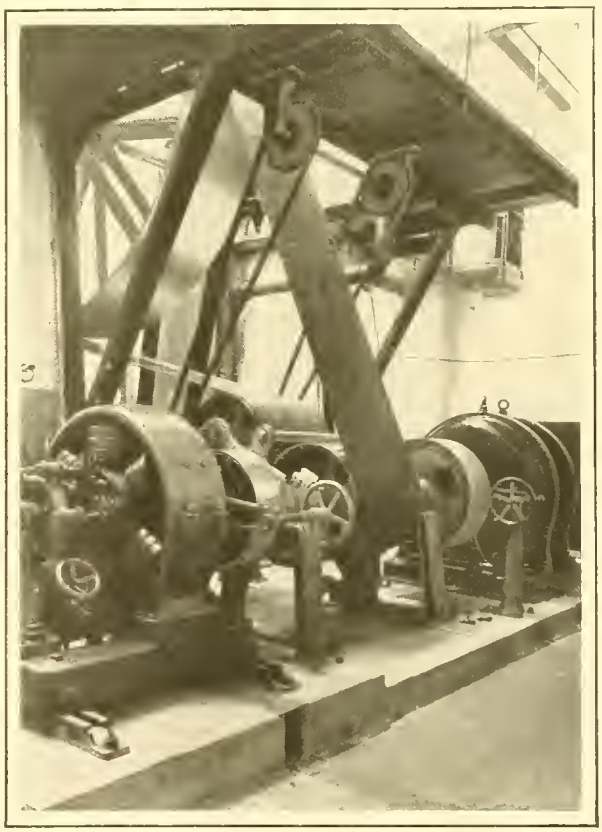
Application of the Lenix System with 36-In. Belt and Shafts 17½ Ft. Apart



Elevation Showing the Cramped Quarters of the Belt Transmission

An interesting case of the transmission of a large amount of power in close quarters with a speed reduction of 5 to 1 is shown in the accompanying reproduction of a photograph taken in one of the largest woolen and spinning mills in Europe. It is an application of the Lenix drive, with a double Schieren Duxbak leather belt 900 mm. or 36 in. wide.

A sketch of the elevation of the transmission system has been drawn and will serve to explain the problem. It will be noted that the driving shaft is nearly 13 ft. below the driven shaft, and that the latter is off-set as regards the necessary location of the driving shaft a distance of almost 12 ft. This places the two shafts parallel to each other at a distance of 17 ft. 6 in., and to transmit the required amount of power with the speed reduction desired, the Lenix drive was installed. This, of course, comprehends the use of an idler held against the belting to secure the desired arc of contact. It will be noted that the Lenix pulley is hung by means of two link belts or chains, running over sprockets hung from the balcony shown above the driving shafting, and the free ends of these chains carry a series of weights, hanging in pits below the floor level, so that the upward pressure or position of the Lenix idler may be as desired, depending upon the power to be transmitted and therefore the arcs of contact between pulley faces and belting. According to the sketch, it would appear that the arc of contact of the driving pulley is about 215 deg., and that of the driven pulley about 230 deg. With a speed of the driving shaft of 600 r.p.m. and a desired speed of the driven shaft of 120 r.p.m. the diameters indicated were chosen.



We have a very interesting and instructive Booklet on the Care and Upkeep of Leather Belting. It's written by our superintendent and sent out Free.

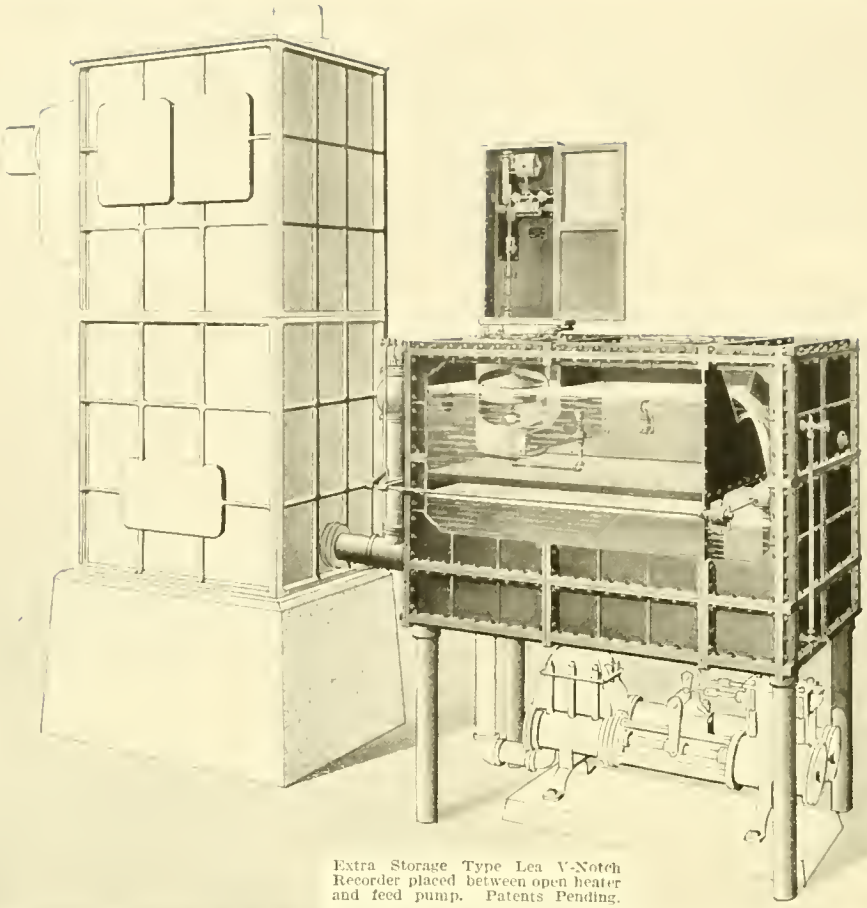
This trade-mark DUXBAK BELTING TRADE MARK stamped every ten feet on genuine "Duxbak" Belting

Chas. A. Schieren Company
ESTABLISHED 1866.

TANNERS AND BELT MANUFACTURERS

25 Ferry Street — New York City

Chicago	128 W. Kinzie Street
Boston	641-643 Atlantic Avenue
Philadelphia	226 North 3rd Street
Pittsburgh	205 Wood Street
Denver	1752 Arapahoe Street
Seattle, Wash.	620 Fourth Avenue
Hamburg, Germany	Auf dem Sande 1
Milan, Italy	Piazza, Castello 3
Vienna, Austria	Dominikanerbastei 24
Oak Leather Tanneries	Bristol, Tenn.



Extra Storage Type Lea V-Notch Recorder placed between open heater and feed pump. Patents Pending.

A Compact Installation—An Efficient Combination

Above is shown a compact installation of an extra-storage type "LEA" V-Notch Recording Liquid Meter (Patents Pending), an open heater, and a feed pump. This "LEA" is measuring boiler feed by the natural law of gravity—water flowing over a v-notch weir, the volume of which is a known quantity—and making a graphic record on a chart in the steel recorder case on top of the tank.

"LEA" V-Notch
Recording Liquid Meter

"Log-Book of the Power Plant"

The extra storage type "Lea" has an extra-long still-water chamber above the weir, and an even longer storage chamber below the weir. The longer storage space insures a steady chart record and a uniformly accurate curve, even under badly fluctuating feed.

There are nearly a thousand "Lea" V-Notch Recording Liquid Meters in use all over the world, reducing coal consumption and increasing the general efficiency of power plants. Mail the attached coupon for new valuable printed matter that will help you decide what the "LEA" would do for you.

YARNALL-WARING CO.
Chestnut Hill, Philadelphia

Makers of the Simplex-Seatless Blow-Off Valve, Simplex Pipe-Joint Clamp, and other Specialties

YARNALL-WARING CO.
Chestnut Hill, Philadelphia

Gentlemen:—You may send me the new free printed matter on the "LEA" Recorder.

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Materialize Your Ideas

IF you have a new idea which you wish to put into form our whole plant is at your disposal. We are a mechanical clearing house, receiving your plans and issuing completed machines to order. **Forty years' experience in building special machines** for knitting mills, paper making, wood working and nearly every other kind of purpose, has fitted us to help you solve your problems.

A MODERN SHOP AT YOUR DISPOSAL

Let us build your special machine or furnish you with machine work on a contract basis in our large up-to-date factory. The methods and tools we employ insure rapid production of accurate work at a reasonable cost.

If you will send us a blue print we will promptly quote on same. If you prefer we shall be very glad to have one of our Mechanical Engineers call on you.

We hold all Plans and Execute all Work in Strict Confidence

C. H. COWDREY MACHINE WORKS

Fitchburg, Mass.

SET-BACK COUNTERS—revolution, direct drive and rotary ratchet—are the newest offerings of the VEEDER line which has set a world famous standard for compact construction and mechanical efficiency in operation.

The set-back or lock-wheel counters are specially suitable for punch presses, looms, stamping machines, duplicators, addressographs, mimeographs, coil winders, pumps, engines, screw machines, typesetting machines, or any machines on which an accurate record of parts made is desired.

SET-BACK COUNTER
(½ actual size.)

VEEDER Clutch Speed Counters are absolutely reliable instruments for the indication of speed.

The VEEDER FORM C TACHOMETER is a portable instrument for indicating revolutions per minute of dynamos, motors, shafting, etc. The only moving part is the paddle wheel in the centrifugal pump. This has radial blades and hence indicates when run in either direction. When paddle is revolved, the liquid is forced out of pump and up the indicating tube by centrifugal force.

Every mechanical engineer should have a copy of our booklet "Counters." It contains a detailed description of the application of 25 different styles of counters. SEND FOR IT TO-DAY—IT'S FREE.

The Veeder Manufacturing Company

C. H. VEEDER, President. H. W. LESTER, Secretary D. J. POST, Treasurer

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FOSTER ENGINEERING COMPANY

Manufacturing Engineers of Automatic Valve Specialties

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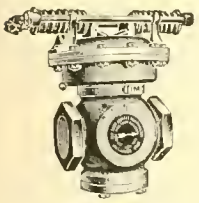
Products

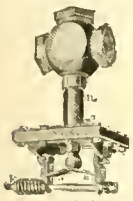
The "Foster" Pressure Regulators; Pump Governors, Non-return Stop Valves; Emergency Stop Valves; Float Valves Back Pressure Valves; Fan Engine Regulators; Free Exhaust or Atmosphere Relief Valves; Lever Balance Valves; Hydraulic Reducing, Regulating and Relief Valves; Vacuum Regulators, and kindred devices.

Class W Pressure Regulators



Designed to maintain a constant terminal pressure of steam, water, gas or air, under certain conditions, from an available initial or supply pressure in excess of same. Simple in construction, rugged, compact, easily repaired. Ample capacity, no dash pot, noiseless, no small parts to stick. Diaphram actuated with compensating springs externally fitted. Suitable for initial working pressures up to 250 lbs. and for terminal pressures of from 5 to 125 lbs. (dependent on spring power). For service where demand at reduced pressure is fairly constant.

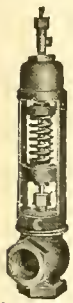
Classes Q. and Q. H. Pressure Regulators



A sensitive, reliable Regulator for heating systems (air or steam). A high-grade low pressure Regulator. No weights or close fitting pistons and is easily adjustable for pressures desired between 0 and 15 lbs. The most reliable steam heating Regulator produced—upkeep reduced to minimum. Made in sizes ¾ inch to 12 inches. Smaller sizes 2 inch and under are fitted with brass bodies; larger sizes have iron bodies, composition mounted and composition renewable seats.

"Q. H."—Same Valve with differential inlet and outlet connections facilitating easy application to enlarged outlet piping connections.

Piston Actuated Pump Governor

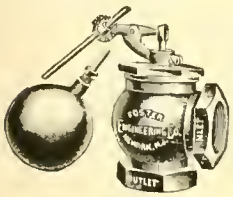


Designed for general service and to meet the demand for a Pump Governor that controls the discharge pressure from the pump. Fitted with renewable composition discs, easily and quickly renewed, insuring tight seats. An extremely simple, self-contained Governor—set the adjusting spring for the desired discharge pressure from pump and the Governor will do the rest. Made in angle and straightway body. Sizes one-half to two inches, inclusive, all composition. Two inches and larger, iron body, composition mounted. Will give closer and longer continuous service than any other similar Valve on the market.

Foster Back Pressure Valve

The Foster Back Pressure Valve aims to reduce common difficulties usually experienced with inefficient competitive products, and was designed to meet the demand of modern practice. Does not chatter. Durability, reliability, functioning power at any pre-determined pressure—0 to 15 lbs.—fully assured. The only thoroughly cushioned self-contained Back Pressure Valve on the market. Made in flanged ends, sizes 2½ inches to 20 inches.

Foster Float Valve



Auxiliary operated (can also furnish "direct acting types"). Quick, sensitive and positively non-leakable; is not cumbersome or frail in construction. Functions with the pressure in supply pipe; may be located at any desirable point, directly or indirectly connected to a small operating Float in the tank. Invaluable on steam line and automatically controlling admission of steam to pump returning water of condensation. May be used in other ways. Angle and globe bodies. Sizes up to two inches, inclusive, all composition. Larger sizes iron body, composition mounted, with removable seats.

Class G Pressure Regulator

A superior high-grade Pressure Regulator that does not leak or stick. Suitable for final working pressure from 0 to 250 lbs. Single seated, auxiliary operated. Holds tight. Suitable for air, steam, oil or water under certain conditions. (We advise them.) Can be installed equally well on horizontal or vertical pipe. Internal parts are easily and quickly renewed. All auxiliary parts interchangeable. Especially recommended for service where demand for reduced pressure is intermittent.

Class U Pressure Regulator

A water pressure regulator that regulates (equally adaptable for air service under certain conditions). Capable of reducing 300 pounds initial pressure to a final of from 5 to 200 pounds. A strong, rugged, reliable product. For service where a steady, even delivery pressure is required whether discharge lines are open or closed. Main valve is fitted with soft disc, easily renewable when necessary. Globe body only. Sizes ½ inch to 2 inches, inclusive, all composition. 2½ inches to 12 inches, iron body, composition mounted.

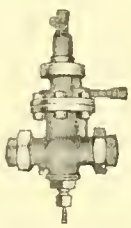
Class G Pump Governor

Auxiliary operated, fitted with diaphram on water end, adapted for any service where a steam driven air compressor or Pump Governor can be used and is, without exception, the most satisfactory Valve that has been produced for the regulation and automatic control of pumps. None better. Recommended for hard service where the most severe and exacting duty and close regulation is desired. Guaranteed to operate within a variation of three pounds or less. Holds tight. Made only in globe bodies. Can be installed in any position. Sizes ½ inch to 2 inches, all composition; 2½ inches to 6 inches iron body, composition mounted. For discharge pressure up to 300 lbs.

Automatic Non-Return Stop Valve

Automatically cuts out a defective boiler in the event of blowing out of tubes, poor firing, etc. By their use the admission of steam to a cold boiler from the battery to which it is connected is impossible. A positive factor of safety. The only thoroughly cushioned Non-Return Valve extant. An equalizing Valve. The "Watch Dog" to the boiler equipment. Does not stick, bind, pound or chatter. Fitted with removable seat rings, keyed. For saturated and (especially prepared) superheated steam. Produced in Angle or Globe Bodies. Semi-steel and cast steel. Designed for service rather than to meet competition.

Foster Class G Fan Engine Regulator

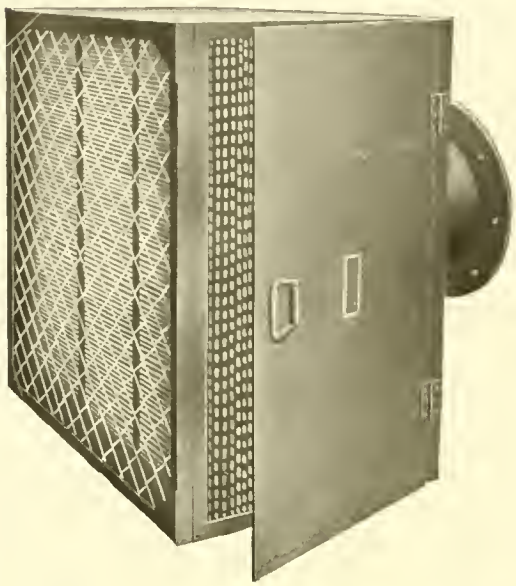


Designed to automatically control direct connected fan engine or jet blower system by the boiler pressure. For forced or induced draft equipment. Simple in adjustment. Guaranteed to operate within two pounds variation in pressure. Solely a high-grade device. Sizes one-half inch to two inches, composition, union ends only. Larger sizes iron body, brass mounted, screwed or flanged ends as desired. Strainers furnished. Requires no manual attention after adjustment.

THESE, AND OUR OTHER SPECIALTIES, FULLY DESCRIBED IN CATALOGUE No. 20.

System of AIR FILTERING

FOR GENERATORS, MOTORS, COMPRESSORS, ETC.



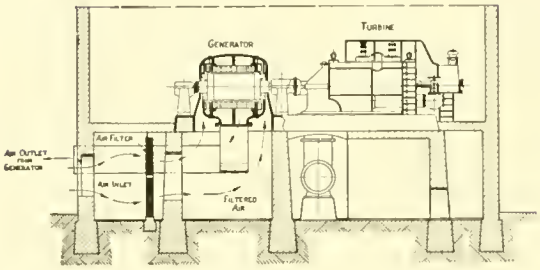


Fig. 3201

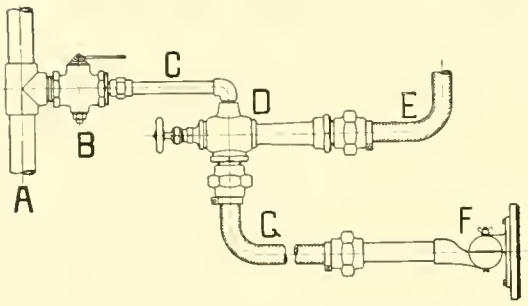


Fig. 3202

A—Main supply line. B—Regulating cock. C—Air or steam line. D—Exhauster. E—Discharge. F—Mouth piece. G—Suction line.

DRY AIR FILTER

Turbo-dynamos, motors and compressors require a large amount of cooling air to insure a low temperature of the inner parts. As atmospheric air, especially in the neighborhood of power plants, contains a large quantity of dust, it has been found not only desirable, but quite often absolutely necessary to purify the air before it enters the machine, in order to keep the inner parts of the rotary machine clean.

In the dry air filter system the ventilators of the generators, or the compressor itself draw the necessary amount of air through the filter windows, which are arranged in a box, on the inlet and discharge side of which a wire screen is provided to prevent large foreign particles from entering the system.

The area of the filter is so dimensioned that a certain velocity is obtained, with which the air travels through the filter windows, and as the foreign particles, such as coal dust and dirt, are heavier than air, they will be thrown against the filter material of the windows where they are caught by the fine cotton strings. The kinetic energy is thus used to eliminate the foreign matters and to obtain clean air.

The system occupies small space, and may be arranged in the basement underneath the generator or compressor (see Fig. 3201), or outside of the power house as conditions may warrant.

The boxes are made in standard sizes, and as many coupled together as required. These boxes are made of angle iron and steel plates, and completely closed on three sides. On the fourth side a door is provided through which the filter windows are inserted, while the front and rear of the boxes are open (except for the wire screen) for the passage of the air.

Cleaning of the filter windows can be done without interfering with the working of the system—simply open the door on one side and remove one window after the other and clean same by means of the portable vacuum cleaning apparatus, Fig. 3202.

The cleaning device (Fig. 3202) consists of a steam-jet Exhauster (d) which creates a vacuum on the suction which is connected to a mouth-piece (f) by means of flexible metallic tubing (g), and the dust thus collected from the filter windows is discharged with the steam into the open air, or under water.

WET AIR FILTER

Contra-Spray Air Washing

Contra-Spray Air Washing is for the purpose of removing dust and foreign particles and at the same time *reducing the temperature of the air* before it passes to the turbo-generators, motors, etc.

The outfit consists of a number of spray or atomizing nozzles installed in a box or chamber, the chamber being so arranged that all air must pass through same and thus become thoroughly washed by the finely divided water.

The eliminator, which is installed behind the spray chamber, consists of a number of baffles so formed as to catch entrained moisture, which drains to the base of the eliminator and is carried off through a drain pipe.

Inasmuch as it is undesirable in most cases to pass too much moisture along with the air to the eliminator, the forward movement of the air is arrested by having the nozzles discharge against each other in contra-spray. The fineness of the spray is equally as good as if the discharge was free.

Water is supplied to the atomizing nozzles by either centrifugal or piston pump, under a pressure of 30 lbs. per square inch at the nozzles.

It depends on the nature of the air or gas to be washed and the amount of dust with which same is laden, if it is possible to use a part of the water over again. Whenever possible this arrangement is to be preferred, in which case a float valve is provided so as to automatically admit make-up water.

Duplex Strainers are arranged in the discharge pipe from the pump to the atomizing nozzles in order to have the water free of dirt and thus prevent clogging. The duplex arrangement of strainer permits of removing the basket of one side for cleaning while the water is passing through the other basket, thus preventing interruption of the system.

We also manufacture:

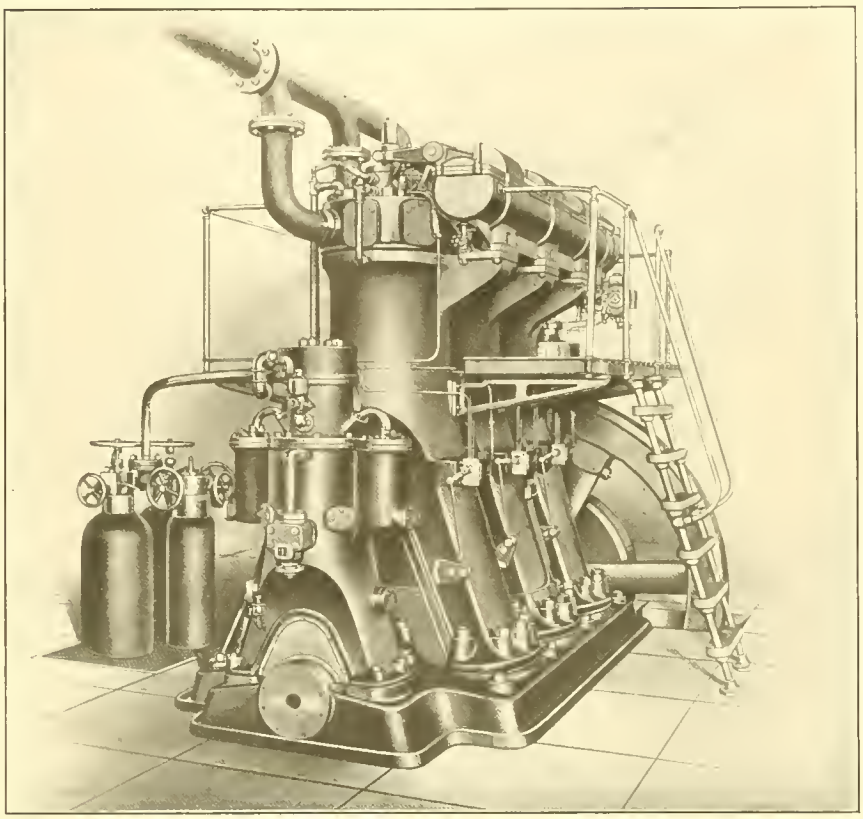
Air Pumps, Rotary
"Airex" Feed Water Air Eliminators
Condensers, Rain and Surface
Condensing Pumping Outfits
Separators, Oil
Traps, Return Steam
Traps, Vacuum Steam

GENERAL CONDENSER CO.

1250 NORTH 12th STREET PHILADELPHIA, PA.

Fulton-Tosi Oil Engines

(DIESEL TYPE)



Economy-Reliability-Simplicity

Designed in accordance with the most approved modern principles.

Operates on lowest grades of liquid fuels without requiring any desulphurizing or refining process.

Fuel consumption less than 6 gallons per 100 BHP hours.

Direct connected injection air compressor forming an integral part of the engine.

Centralized control enabling operator to start engine from one point.

BULLETIN 800 GIVES DETAILS

FULTON IRON WORKS

ST. LOUIS, U. S. A.

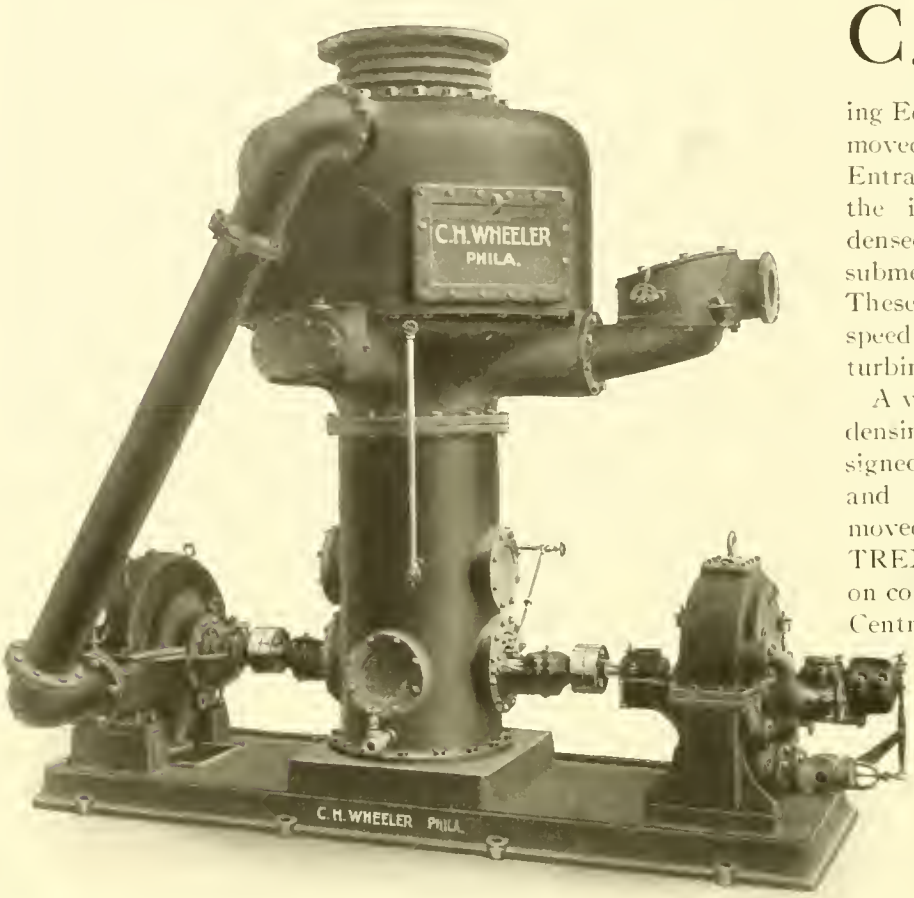
New York Office: 82 Wall Street

Established 1852 Incorporated 1871 New Plant Erected, 1912

"SIXTY YEARS OF SUCCESSFUL MANUFACTURING"

TWO ATTRACTIVE ARRANGEMENTS OF

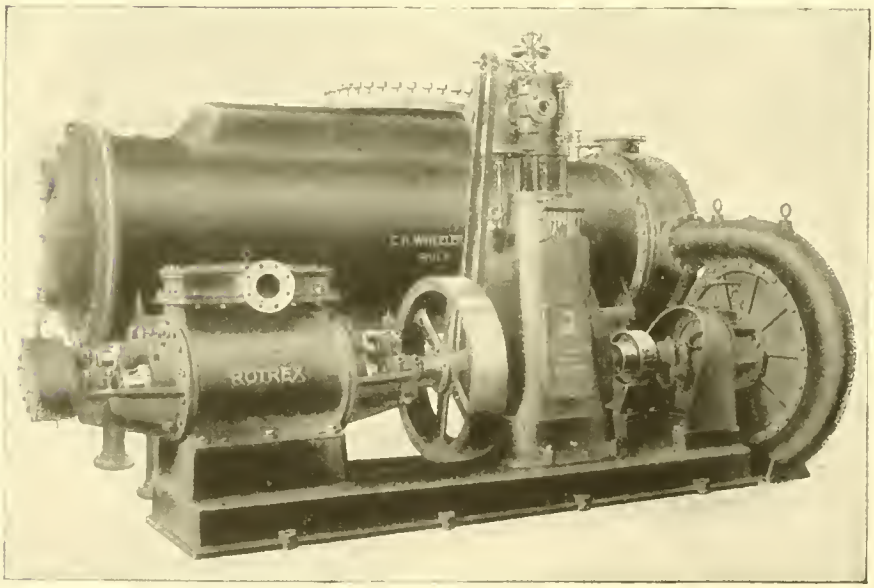
CONDENSING APPARATUS



C. H. WHEELER Improved Counter-current, High Vacuum, Jet Condensing Equipment. The air is removed by a Thyssen Patent Entrainment Vacuum Pump and the injection water and condensed steam are removed by a submerged Centrifugal Pump. These pumps operate at high speed, direct connected to steam turbine.

A very compact surface condensing apparatus, especially designed for low head room. Air and condensed steam are removed by a Pratt Patent ROTREX Vacuum Pump, mounted on common base plate, with the Centrifugal Circulating Pump, both direct connected to a Vertical Enclosed Engine.

We specialize in the design and construction of steam condensing machinery for highest vacuum with minimum power consumption.



Surface, Jet and Barometric Condensers. Water Cooling Towers of the Forced and Natural Draft designs. Vacuum Pumps of the Reciprocating, Rotary and Hydraulic Entrainment types. Centrifugal Pumps, motor, engine, turbine and belt driven. Closed Feed Water Heaters. Special Turbine Exhaust Gate Valves. Copper Expansion Joints. Multiflex Atmosphere ic Exhaust Relief Valves.

"Everything but the Turbine"

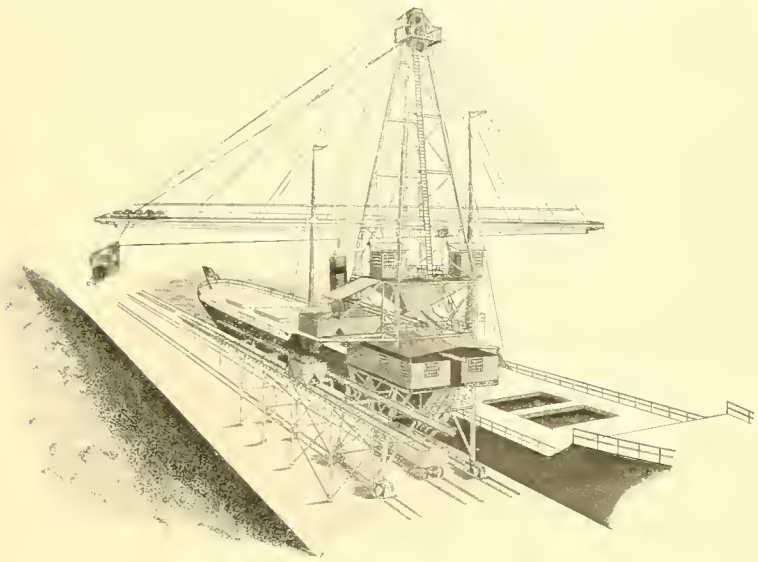
C. H. Wheeler Manufacturing Co. Philadelphia Pa.

BRANCHES: New York, Boston, Chicago, Cleveland, Pittsburgh, Charlotte, San Francisco, Cincinnati, New Orleans

Hunt Coal Unloaders

are rapid, rugged, simple in design, and above all **reliable**

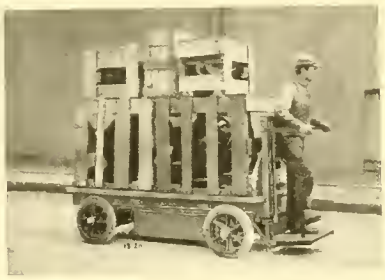
These points were carefully considered by the United States Government before placing contract for six of them for the Panama Canal Coaling Stations. Two of the towers shown in the illustration will be installed at Balboa, the Pacific end of the Canal, and four at Christobal, the Atlantic end, with a combined unloading capacity of eighteen hundred gross tons per hour. They will unload from vessels all the coal delivered on the Canal.



"One of the Six" Hunt Coal Unloaders at the Panama Canal

Think this over. We are specialists in machinery for the hoisting and conveying of bulk materials and have been for forty years. If you have a coal handling problem before you, tell us the requirements which must be met and let us help.

Hunt Storage Battery Industrial Truck



The cuts show our standard 2 ton storage battery truck handling miscellaneous material around a manufacturing plant. Great economies can be effected by the use of this little machine. It is easily operated by one man and will do the work of a fleet of hand trucks.

Write for catalog S. 13-4 and tell us your trucking problem and let us help you solve it.

C. W. HUNT CO. (Inc.)

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MANUFACTURERS OF

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Hauling Engines, Pit Head Hoists, Coke Oven Machinery, Rock Drills, Hammer Drills, Coal Cutting Machines, Car Unloaders, and Pit Cage Couplings.

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Rolling mills of any size and description, Continuous Rolling Mills, Seamless Tube Mills, Tube Reducing Mills, Corrugated Tube Mills, Disc and Tire Mills.

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Complete Shipbuilding Berths, Giant Wharf and Floating Cranes, Special Cranes for Floating and Dry Docks, Tower Cranes, Slip Ways, for Hauling Vessels.

BLAST FURNACES
Inclined Hoists, Scaffoldings and Shells, Unloading Bridges, Pig Iron Casting Machines, Pig Iron Breaking and Loading Cranes.

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Blowing Engines, Converters, Mixers, Openhearth and Electric Furnaces, Charging Machines, Soaking Pit- Stripper- and Ladle Cranes.

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Demag Special Harbor Cranes, Gantry Cranes, Overhead Travelling Cranes, Revolving Jib Cranes, Tilting Hook Cranes for rails, bars, etc., Magnet Cranes.

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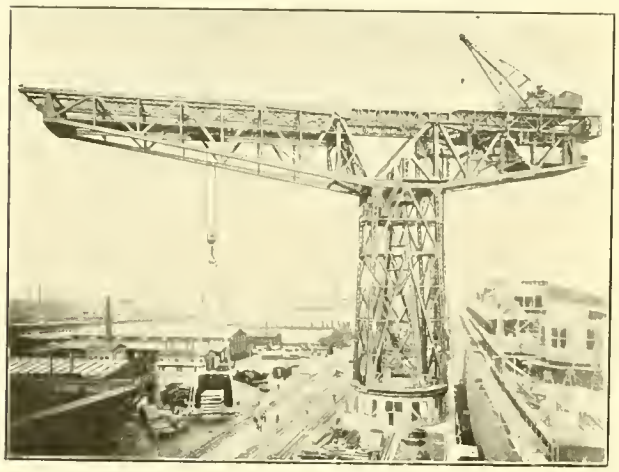
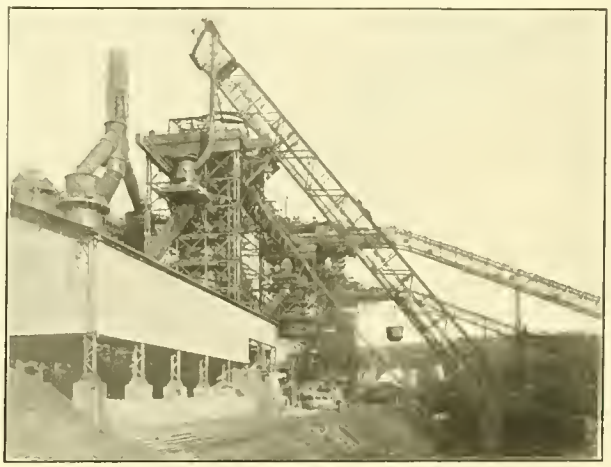
Straightening and Bending Machines, Shears, Saws, Presses, Steam Hammers, Scrap Iron Bundling Presses, Air Compressors, Lifting Magnets, Grab Buckets, Capstans.



LARGEST CRANE IN THE WORLD
Lifting 275 Ton Test Load



MODERN BLAST FURNACE PLANT

**THE DEUTSCHE MASCHINENFABRIK A. G.
EMPLOYS NEARLY 7000 PEOPLE**

among whom there are about 700 expert engineers and draftsmen. It is on account of this large engineering staff that everyone of its various departments is fully as efficient as any individual concern specializing in its particular line.

DEMAG MACHINES ARE USED ALL OVER THE WORLD

They are renowned for their thorough and appropriate designs, careful workmanship and high efficiency.

Descriptive matter on any subject gladly furnished.

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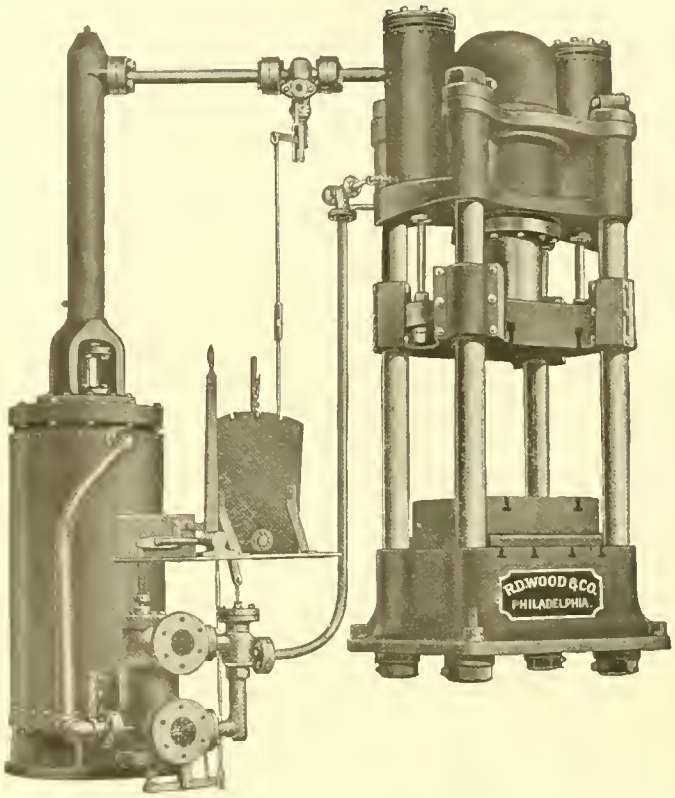
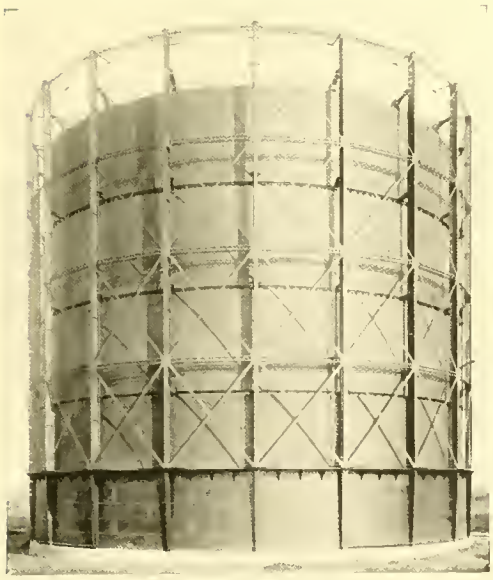
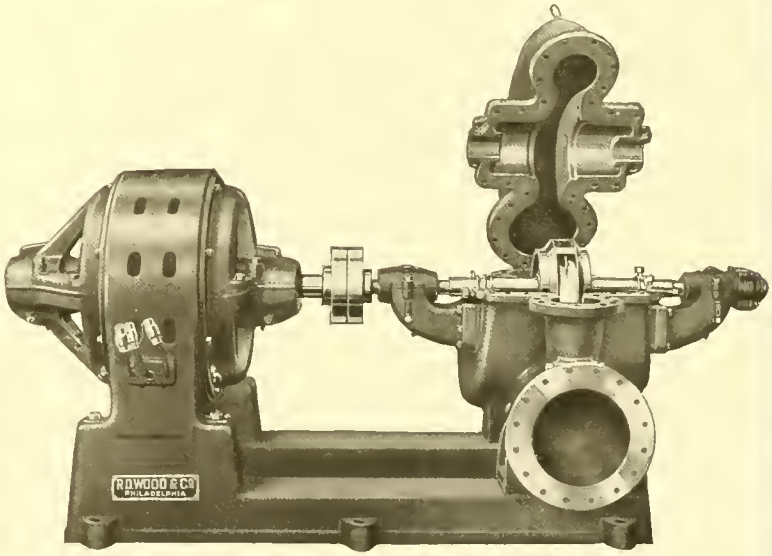


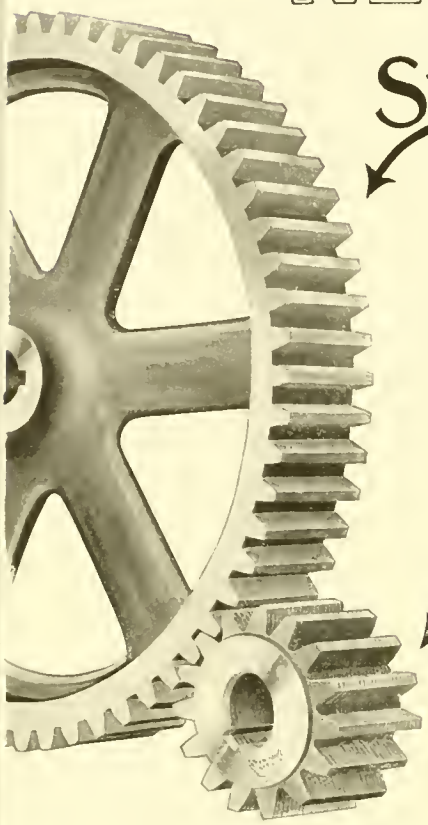




Manufacturers of C. I. Pipe, Gas Works Apparatus, Centrifugal Pumps, Hydraulic Tools of all description, Hydrants and Valves, Gas Producers

When you've tried others and want something better-

NEW PROCESS



Steel or Iron Gears

We have the best facilities for the economical production of spur gears, bevel gears, spiral gears and internal gears, soft or hardened. Our output averages several thousand gears per day.

Noiseless Pinions

Absorb vibrations and protect the intermeshing gear teeth—in fact the entire machine—much like the automobile shock absorber takes up shocks and protects the automobile tires, springs, body, etc. This is proved wherever New Process Noiseless Pinions are used.

Besides, it is firmly established that no other rawhide approaches New Process in strength and long life.

Made in every desirable type and size and more extensively used than all other makes of rawhide pinions put together.

You can't estimate gear costs correctly without our quotation, for our modern equipment, 25 years' experience and the world's largest gear plant fit us well to handle repair jobs or quantity orders at very reasonable prices. **Try us on one order.**

NEW PROCESS IS TO ALL OTHER RAWHIDE AS STEEL IS TO IRON

N.P.R.H. REG U.S. PAT OFF

NEW PROCESS GEAR CORPORATION

SYRACUSE, N.Y.

CANADIAN AGENTS: Robert Gardner & Son, Ltd., Montreal

In an Age of Steel–
Steel is the Best Pulley Material

WHEREVER strength combined with lightness is desired, whether in the skeletons of sky scrapers or in watch springs, steel is used. These same qualities make steel the logical pulley material.

"American" Steel Split Pulleys

are probably more numerously used than any other make of metal pulley, and more than of all other steel pulleys combined.

Of the more than 2,000,000 "American" Pulleys shipped from our factory, less than two-tenths of one per cent have been reported as failing in service.

"American" Pulleys are light, strong and practically indestructible. They may be bushed down so as to take an immovable grip on various sizes of shaft.

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Write for "Factors of Energy"

a booklet containing tables, measurements, and notes of interest to the millman.

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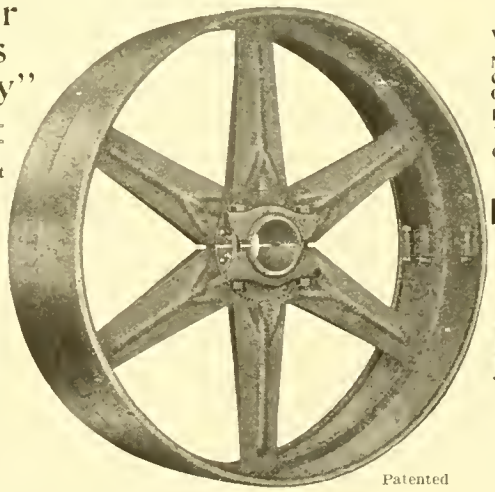

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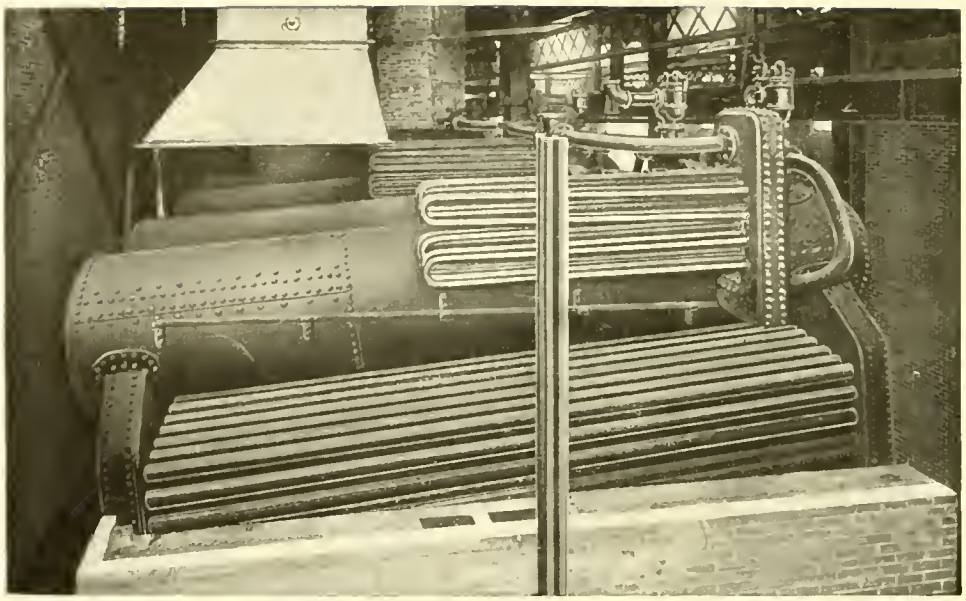
Perfect in Principle

Powerful in Performance



A Battery of Heine Boilers and Superheaters in Course of Erection in a Large Central Station

For Turbine Work Use The

Heine Superheater

THE above photograph shows a battery of Heine Boilers equipped with Heine Superheaters in the course of erection in a modern central station. Steam is furnished to a number of 4000 KW. Turbo-Alternators.

Superheat is of prime importance for all steam motors because it increases the difference between the temperatures at which the heat is supplied and rejected, and therefore increases the thermodynamic efficiency. Furthermore, with steam turbines, superheat reduces the blade friction losses, and thus increases the percentage of the available energy, delivered at the switchboard. There is an increase in the Rankine Efficiency.

In installing superheaters, however, it is important that a type be selected with which the steam temperature cannot rise to an excessive degree and cause mechanical troubles with valves and fittings. This is especially liable to occur where superheaters are installed so that all the gases pass over them, **with the result that when the boilers are driven at high capacities, the superheater is also driven hard and the temperatute becomes excessive.**

In the Heine Superheater dampers control the amount of gas flowing over the superheater tubes, and therefore permit of accurate regulation of the superheat temperature at all loads, drafts, and conditions of fire. A small part of the combustion gases pass up a flue in the side walls, and after making two passes over the superheater tubes, join the boiler gases and pass to the uptake. Besides giving control of the superheat temperature, **Heine Superheaters have the important advantage of not requiring flooding, since when no superheat is required the hot gases are cut off from the superheater tubes. As flooding is unnecessary, scale-forming impurities are not deposited in the tubes.**

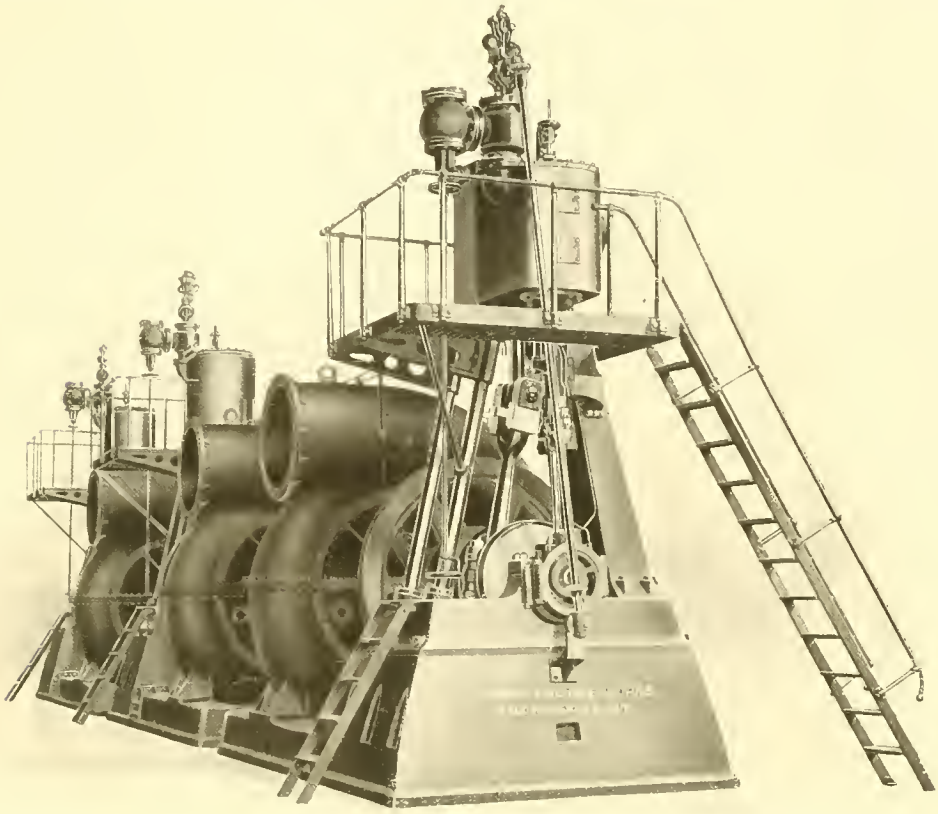
For further information write for our booklet "Superheating"

HEINE SAFETY BOILER CO.

2465 E. Marcus Ave. **St. Louis, Mo.**

CENTRIFUGAL PUMPING MACHINERY

Nearly fifty years' experience in building Centrifugal Pumping Outfits, covering all services for which Centrifugal Pumps have been used, ought to count for something in the building of a Centrifugal Pump.



There is no problem, no matter how difficult, where a Centrifugal Pump can be used but what we have a type to fit the case and do the work efficiently and economically.

Let us know your requirements and we will recommend the best pump for the service.

Our new illustrated catalogue is now ready and we invite your correspondence.

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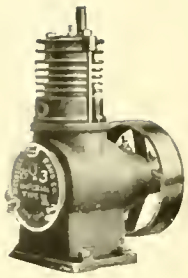
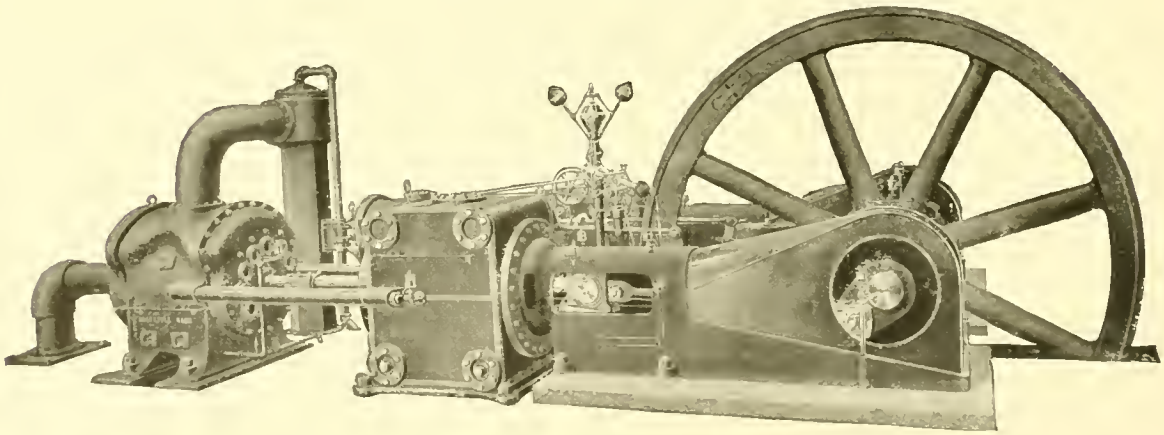
EXTREME  LIMITS

Above is shown the Smallest Compressor in the Ingersoll-Rand line. Air Cooled-Power Driven 3.8 Cu. ft. Capacity.

There are over 1000 sizes of INGERSOLL-RAND air compressors between the two limits shown—Steam, Belt, Short Belt Electric and Electrically Driven—Straight Line and Duplex types. All of these machines show the same care and attention to details of design, materials and workmanship—they are the very best. One of these machines is the one you are looking for.

Bulletin 3101 Covers the Line

Below is shown the Largest Air Compressor in the Ingersoll-Rand line — Corliss Engine Driven — 9330 Cu. ft. Capacity.



INGERSOLL-RAND COMPANY

NEW YORK — Offices All Over the World — LONDON

24-C

The Wire Rope

of which a piece, the exact size, is shown above was made recently at the Roebling works for the final stages of digging the Panama Canal. It is the largest wire rope shipped to Panama, and, in keeping with the character of the work, is the largest wire rope ever made to run over sheaves.

The rope is a dredging rope, is 3¼ inches in diameter, and has a breaking strength estimated at 400 tons. The wires are drawn from ROEBLING IMPROVED PLOW STEEL. The outer strands, 6 in number, contain 37 wires each and are twisted around an independent wire rope center, which is composed of 6 strands of 19 wires each and a *blue* hemp center.

The hemp centers of wire ropes made of ROEBLING IMPROVED PLOW STEEL are colored *blue* to distinguish ropes so made from all other wire ropes. It is important to make this distinction, for the same degrees of strength and resistance to wear cannot be obtained from any other steel.

John A. Roebling's Sons Co.

Trenton, N. J.

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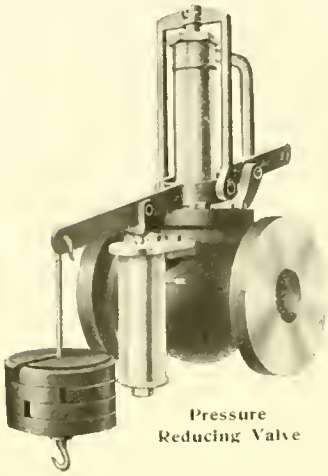
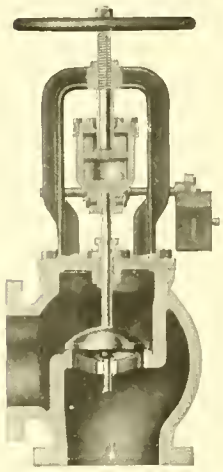
The conservative manager, the shrewd buyer and the efficient operative all agree on the wisdom of using



Pressure Reducing Valve

Davis Valve SPECIALTIES

For thirty-nine years we have been making valve specialties for Power Plants and Heating Systems. This long experience is reflected in the design and construction of the goods which we offer you today.

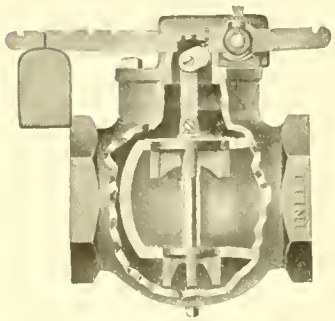


Stop and Check Valve

Whether your needs call for a Pressure Reducing Valve—Stop and Check Valve—Back Pressure Valve—Steam Trap—Pump Governor—Balanced Valve—Float Valve or Exhaust Relief Valve, let your choice be a Davis and you will have no cause for regret.

"We have used a Davis Regulator in our plant for the last 15 years and do not think it has ever given us ten minutes trouble," wrote the Cedar Rapids Pump Co. Such service is the rule and may be expected from Davis Valve Specialties.

With full confidence of being able to make good we unconditionally guarantee Davis Valves to operate to your entire satisfaction. Let us quote on your present requirements and send a catalog for reference.



Back Pressure Valve

Jobbers and dealers everywhere sell Davis Valve Specialties

G. M. Davis Regulator Co.

Established 1875

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Philadelphia, 2528 N. American St.
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THE BOX CRANE

"Ask the Man Who Owns One"

Seaboard Steel Casting Company

Twelve years ago we installed the above cranes which have been running continuously ever since with very little expense for repairs and are as good to-day as the first day they ran. Our new Crane Bulletin No. 800 will show you the wonderful improvements we have made, which are too numerous to mention here. It is worth sending for.

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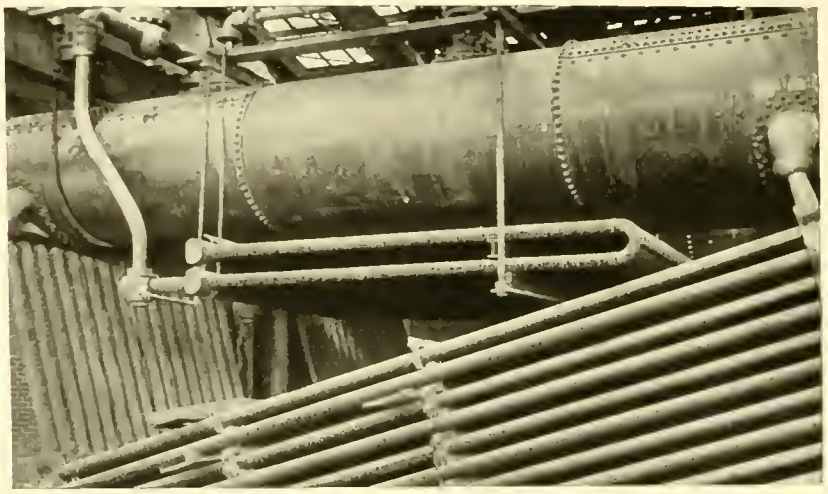
Will give increased efficiency and economical results in the operation of any plant using steam. Can be applied to boilers of any type, old or new.



FOSTER SUPERHEATER IN BABCOCK & WILCOX BOILER

Foster Superheaters are made for every class of service, either combined with boilers or separately fired. The exterior surface is protected from the destructive action of hot gases—a feature which distinguishes the Foster from all other types.

Perfect Steam Circulation **Any Temperature Desired**
Uniform Superheat **Freedom from Repairs**
Over a Million Horse Power in Use

Gaskets for high temperature steam pipes; Piston-rod packing for superheated steam; Ram and Plunger Packing for high-water pressures.

We will be glad to send you some interesting and useful publications dealing with the subject of "Superheated Steam."

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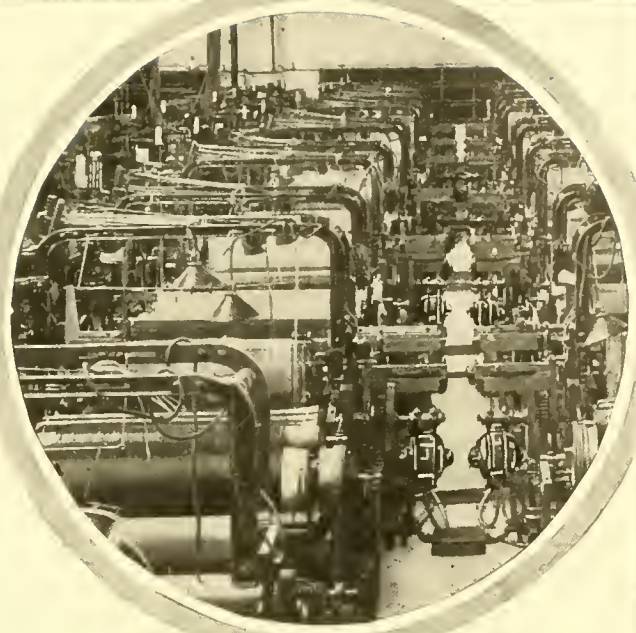
MECHANICAL DRIVE



ELECTRIC DRIVE

The Most Useful Power for the Least Money--From Any Source

Comparing the mechanical lineshaft drive from engine with the G-E individual motor drive in a textile mill as shown above, brings out general truths applicable to every industry. Every man wanting more power, or desiring to pay less for power should read these comprehensive facts:

More power can be generated from a given amount of coal, over extended periods with less maintenance, by using a Curtis Steam Turbine than with any other power equipment. You get maintained efficiency without constant valve grinding and repairs due to many moving parts.

More useful power can be generated from a given amount of water, oil, sun or wind power where the power is to be conveyed any considerable distance, by G-E generators than with any other equipment. More power can be obtained at the place where it is to be used with electric transmission, if the distance is considerable than with any other form of power transmission. This is due to the high efficiency and long life of G-E generators coupled with the elimination of power losses in transmission due to steam condensation, lineshaft friction and belt slippage.

More control over power is obtained with G-E equipment than can be obtained with any other on the market today. There are more types of control equipment manufactured by the General Electric Company than by any other company in this country. These equipments provide any degree of speed variation desired immediately and with absolute certainty. The General Electric Company makes a motor for every power requirement, a controller for every motor, and has skilled engineers to combine them properly.

It will be profitable for you to consult us. The assistance of any part of our organization in solving your power problems is extended to your local power company, or our nearest motor agency.

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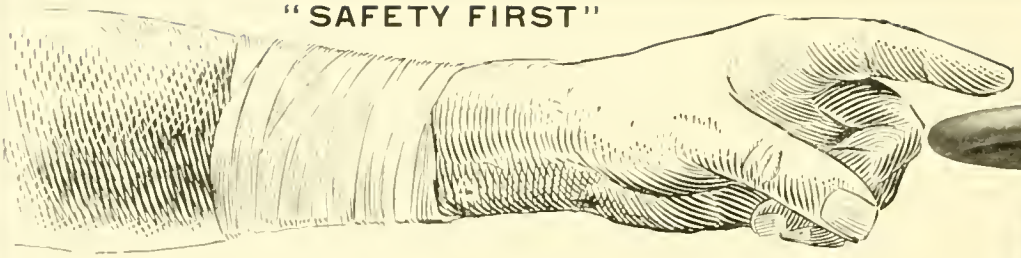
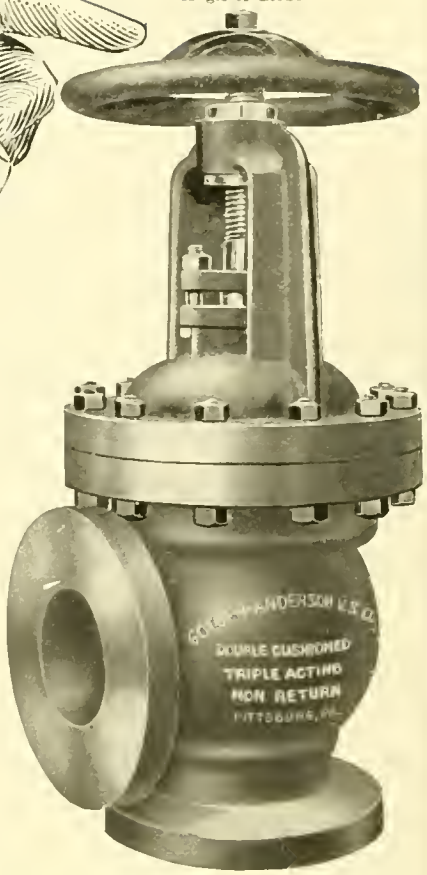
"SAFETY FIRST"



"Angle or Globe"



"That valve saved my life"

"Yes, sir, I owe my life to that valve. Last April, just as I was cutting in Unit No. 3, the 6" separator burst.

"Stunned by a flying bit of metal, I fell across the turbine casing and directly underneath the rupture.

"Of course, I was burned and scalded—but you'd never have found me here today if the live steam flow hadn't been shut off from EVERY boiler in the plant THE INSTANT THAT THE ACCIDENT OCCURRED by the

Life and Property Insurance Valves

we recently installed at all our boiler nozzles."

These valves are also known as the Golden-Anderson Automatic Double Cushioned Triple Acting Non-Return Valves.

They protect the entire plant by working "both ways."

Instantly close and shut off the steam flow to a boiler if a tube ruptures or other leak occurs.

Instantly close and shut off the steam flow from all boilers simultaneously when any steam pipe gives way.

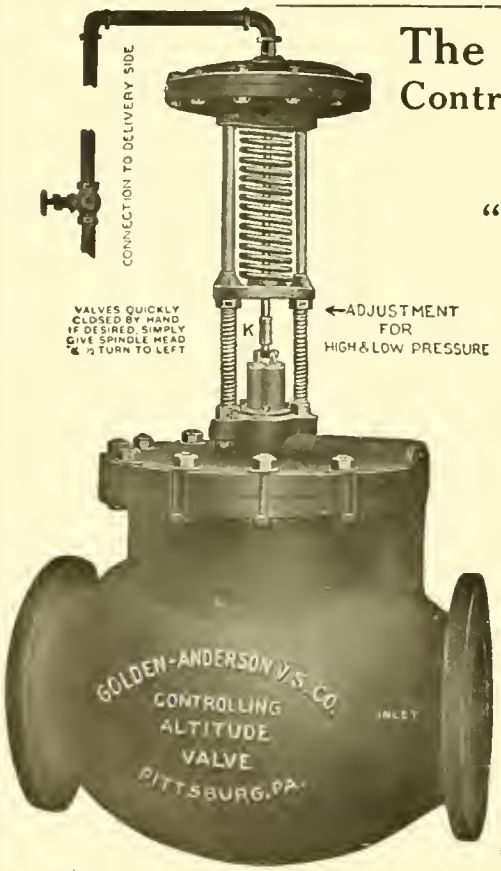
They equalize pressure between all boilers, cannot open until pressure in boiler is equal to that in steam main. Absolutely prevent steam being turned into a cold boiler.

May be closed by steam or electricity from any distant point, or by hand like ordinary stop valve.

Can also be furnished as plain non-return valves for boiler protection only.

The U. S. Steel Corporation has ordered 1193 for the "Protection of their Power Stations"

Can you afford to leave YOUR plant unprotected?



Up to 24".
Angle or Globe Pattern

The Patented Cushioned Controlling Altitude Valves

"Always Cushioned in Opening and Closing"

"For High and Low Pressure"

For automatically maintaining Uniform Stage of Water in Tank, Reservoir on Standpipes. Doing away with the annoyances of Float Fixtures.

"Three ways of closing these Valves"

1st—Automatically by Water.

2nd—By Electricity.

3d—By Hand.

"No Metal to Metal Seats"

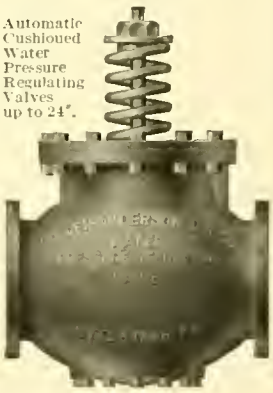
Altitude Valves can be arranged with "Stop Check feature" to automatically close should break occur in the Mains, thus preventing the flow of water from the tank standpipe or reservoir.

Also can be arranged to work "Both Ways."

Golden-Anderson Float Valves

(Angle or Straight Way) up to 24".

Automatic Cushioned Water Pressure Regulating Valves up to 24".



Golden-Anderson Valve Specialty Company

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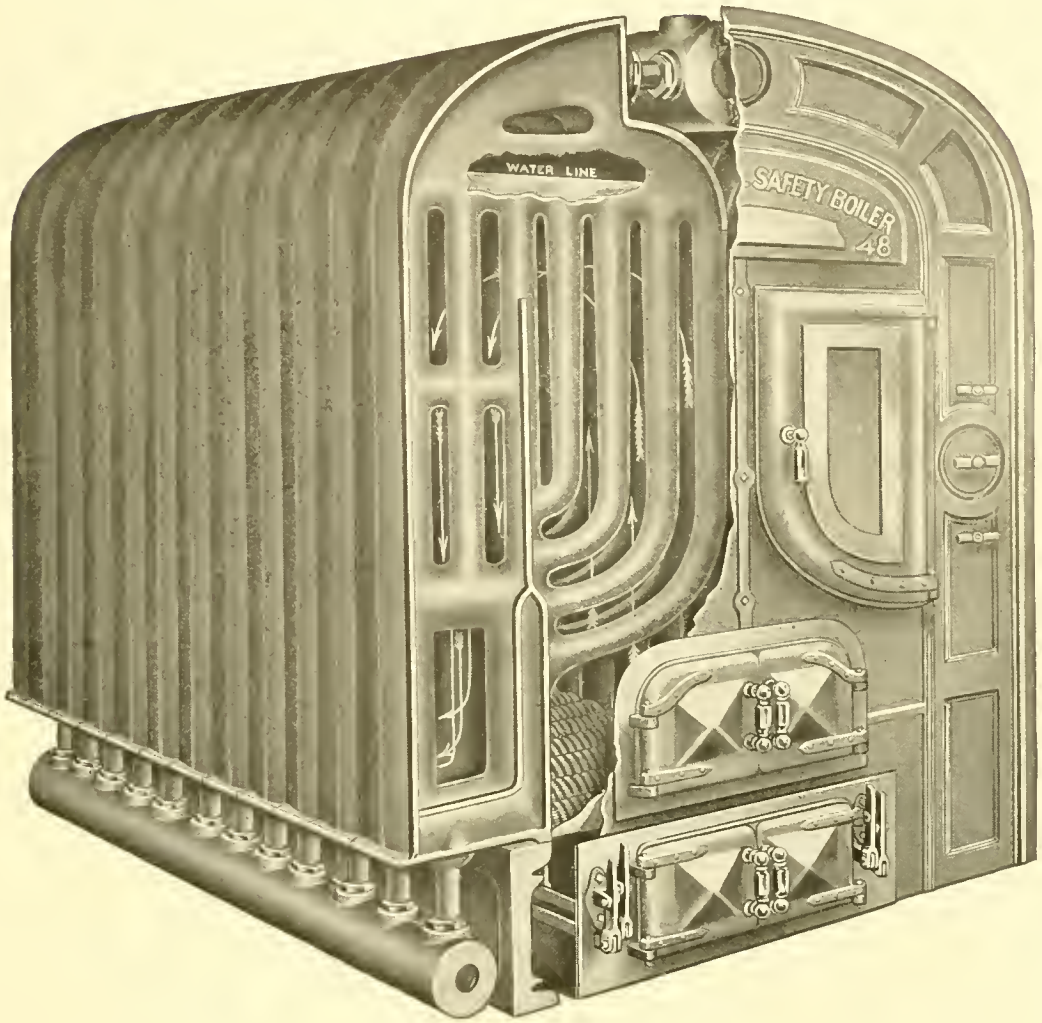
Water Tube Boilers

For Steam and Water Warming



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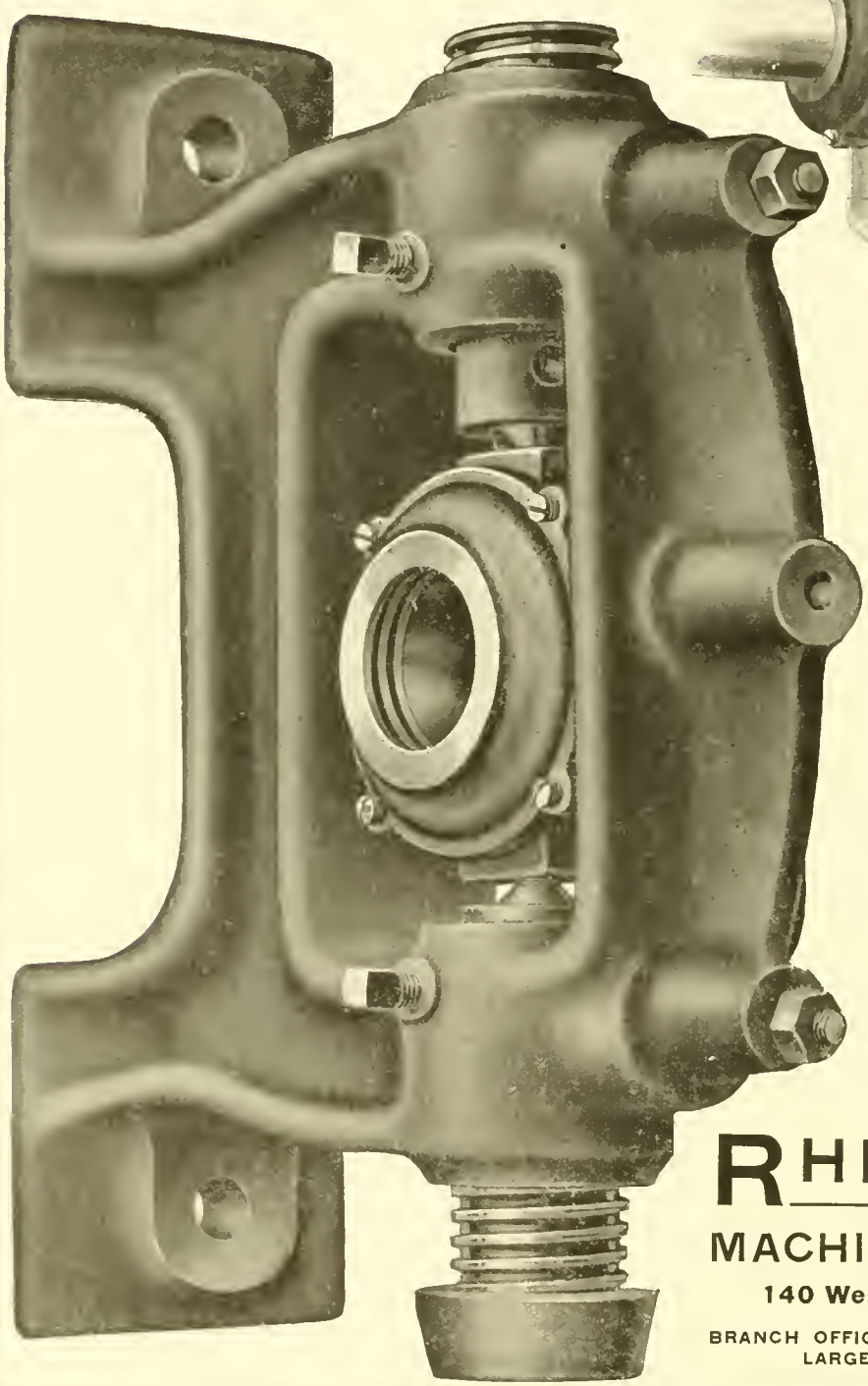
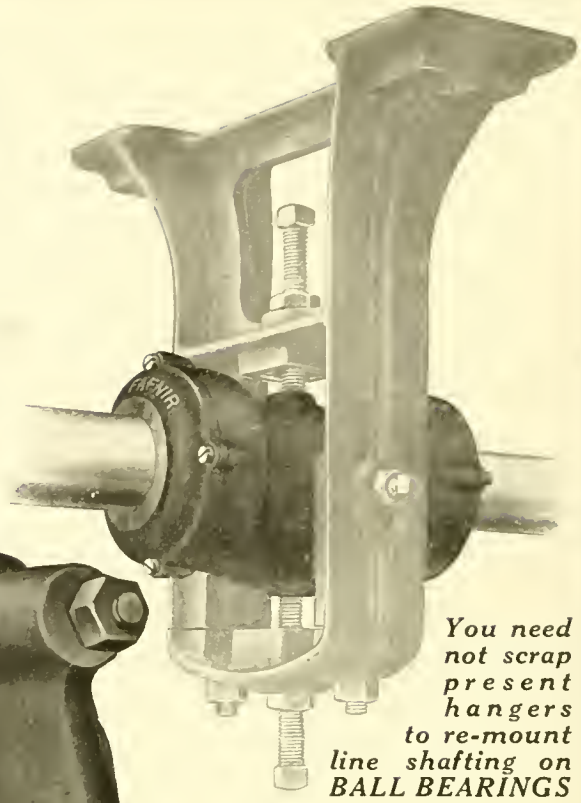
BALL BEARING DROP AND POST HANGERS





You need not scrap present hangers to re-mount line shafting on BALL BEARINGS

Professor John Goodman stated in a paper before the British Institution of Civil Engineers in 1912 that power could be more efficiently transmitted by line shafting than by any other means, *providing the shafting was mounted upon ball bearings.*

Experience in the testing of ball bearings had so convinced him that he was quite willing to bear all the expense of a set of experiments if he failed to demonstrate the truth of the statement.

Properly mounted ball bearings permit the transmission of power over long distance and with very high efficiencies, hence we have developed an extensive line of ball bearing drop and post hangers, pillow blocks, etc., to meet all shafting requirements.

Changing over from plain bearings to get the savings possible only with Fafnir Ball Bearings involves no big expense—you merely substitute the box shown above for your old one.

Try this idea at least on one shaft. State shaft diameter and number of bearings so that we can quote prices and advise you further.

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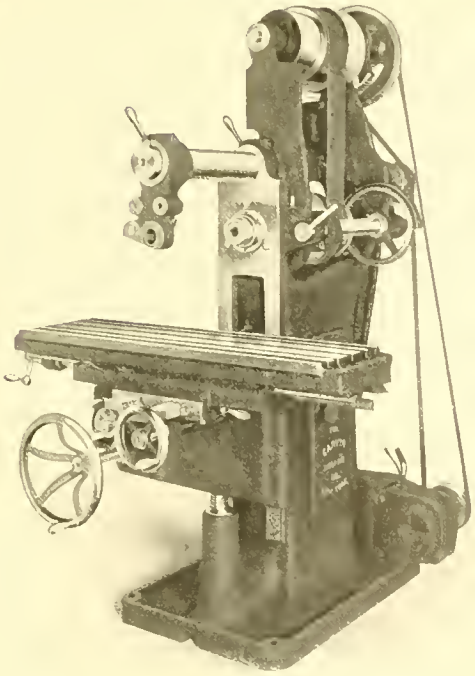

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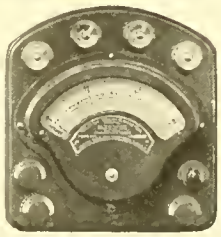
Miniature Precision Instruments for Direct Current

MODEL 280, Single Range Portable Voltmeter. (One-quarter Size.)



MODEL 280, Triple Range Portable Volt-Ammeter. (One-quarter Size.)

A new group of very small Indicating Instruments
COMPACT — ACCURATE — DURABLE — BEAUTIFUL

PORTABLE

Voltmeters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters, are supplied in single, double and triple ranges.
The triple range volt-ammeter comprising six instruments in one. This group also includes BATTERY TESTERS.

SWITCHBOARD

Voltmeters Volt-Ammeters Ammeters Mil-Ammeters

This new line of instruments represents the latest development of the pivoted moving coil, permanent magnet type for low ranges.

The refinement of design and mechanical work in them has been carried to a degree which would appear to be almost impossible of accomplishment, if the results were not evident in the instruments themselves.

They embody characteristics which have made the well known Weston Standards famous throughout the world.

They are accurate, dead beat and extremely sensitive.

They may be left continuously in circuit at full load without injury and are shielded against the external electrical and magnetic influences of other apparatus in their vicinity.

They are substantially constructed and may be safely sent long distances through the mails and will withstand an extraordinary amount of vibration without injury.

They have the longest scale ever provided in instruments with equal length of pointer.

Each model has been thoroughly tested under the most severe conditions of service and in experiments extending over more than one year.

The portable instruments may be conveniently carried in the coat pocket.

The prices have been established upon so low a scale that any one may possess one or more of these remarkable instruments at moderate cost.

If you cannot obtain the instruments desired from your dealer, write us.

The several models and ranges offer a selection from over 300 different combinations, listed in Bulletin No. 8. Will be mailed upon request.

MODEL 267, Switchboard Ammeter. (One-quarter Size)

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GAS ENGINES

FOR ANY FUEL GAS

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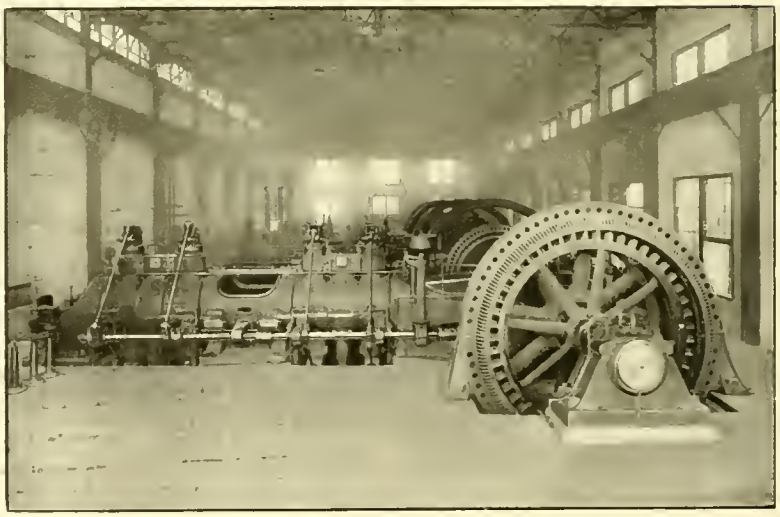
GAS BLOWING ENGINES

EQUIPPED WITH

MESTA PLATE VALVES

(IVERSEN PATENT)



WITHIN 18 MONTHS, 21 COMPANIES HAVE EITHER ADOPTED THE

MESTA BLOWING ENGINES

EQUIPPED WITH THESE VALVES OR HAVE ORDERED MESTA VALVES TO REPLACE OTHER TYPES

WRITE FOR BULLETINS H &

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PITTSBURGH, PA.

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WORKS: MESTA STATION, P. R.R., WEST HOMESTEAD, PA.

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Material, Design and Workmanship Determine its Service and Length of Life

Readers of this publication are competent to pass judgment on the Mathews Gravity Roller. The above is an accurate reproduction of every roller used in the Mathews Standard Gravity Conveyer, and we submit for your approval the following points of superiority:

(a)—Full length, 7/16″ machine steel axle, ends terminating in frame rails and securely locked.
(b)—Rollers made of cold-drawn seamless steel tubing, uniform in thickness.
(c)—Ball-bearing made of movable parts consisting of 1 1/2″ sleeve and 1 1/8″ ball cup, forming a ball race which has no stationary wearing point; sleeve and cup case-hardened.
(d)—Close fitting steel housing, making bearing as nearly dust-proof as possible.
(e)—Rollers are assembled in steel frames rigidly and strongly braced. Roller sections are made in standard lengths of four and eight feet, and 90° curves.

NOTE—Next month we will illustrate detail construction of roller frame.

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Cut out this coupon, attach it to your letter head and we will mail our full set of catalogs and bulletins illustrating and describing the Mathews line of Standard equipment, consisting of Gravity Conveyers, Automatic Elevators, Gravity Roller Spirals, Gravity Spiral Chutes, etc. Sooner or later you will have use for the information given in our literature.

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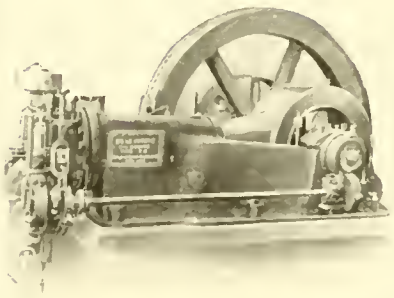
DE LA VERGNE OIL ENGINES



show the highest thermal efficiency of any prime mover. In addition to this, they operate on the heaviest and cheapest grades of fuel oil, such as waste residual tars or asphaltic crude petroleum products which cannot be economically used in any other known way.

This, together with their remarkable high efficiency, makes the **De La Vergne Oil Engine the most economical prime mover on the market today.**

There are over **30,000** of the various types in successful operation.

As many as **eight successive orders comprising forty-two engines in all** have been placed by a single customer for his own use—proof positive of satisfactory service.

No special skill is required to operate them.

They are the ideal source of power for factory service, electric installations, pumping stations and isolated plants of every description.

Send for Bulletin No. 112.

DE LA VERGNE MACHINE CO.

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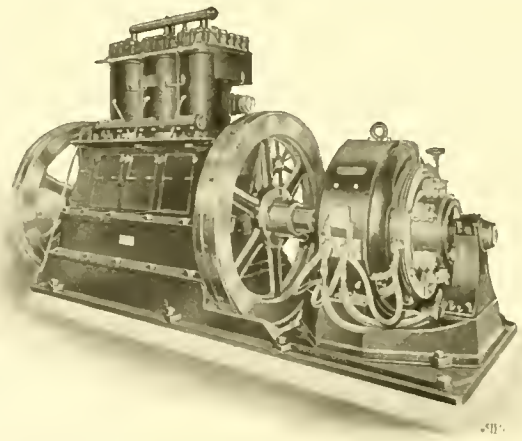
THE NASH ENGINE

ILLUMINATING NATURAL OR PRODUCER GAS.
IS THE MOST RELIABLE AND ECONOMICAL.



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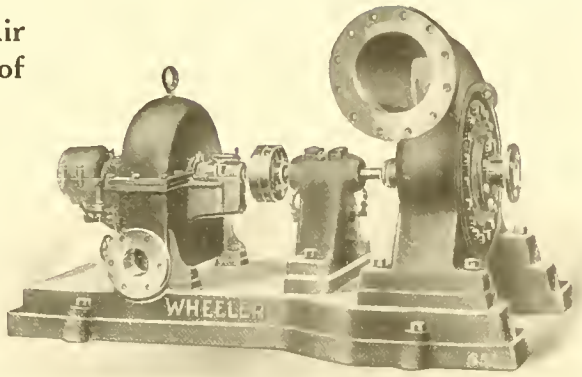
The Wheeler Turbo Air Pump

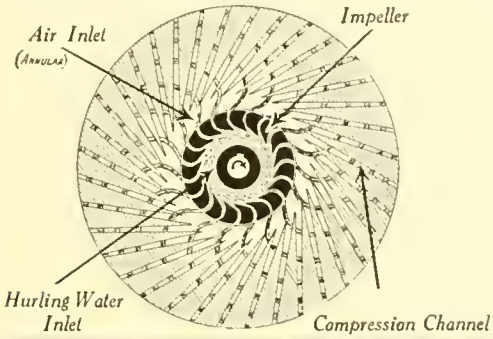
¶ Vacuums of 99 to 100%. ¶ Large Free Air Handling Capacity Insuring Maintenance of Vacuum Under Excessive Air Leakage



The Wheeler Turbo Air Pump is a high speed rotary pump for motor or turbine drive, for use in connection with high vacuum jet and surface condensers.

For surface condenser work the air pump is combined with the hot well pump in one casing, producing a compact unit, driven by a single turbine and connected to the condenser by one pipe, through which both air and condensate are withdrawn.

The design of the Wheeler Turbo Air Pump is based on that of the German pump manufactured by the A. E. G. and is shown diagrammatically in Fig. 2. The essential parts are a small high speed impeller in which the hurling water is accelerated and discharged in a series of jets, second, a ring of compression channels in which the air is compressed by the pistons of water, and third, a casing and discharge volute.



The air enters around the entire periphery of the impeller and is entrapped by the layers of water at the entrance of the compression channels.

The air aspirating effect is positive, resulting in high vacuum efficiency and large free air handling capacity.

Write for our new Bulletin 111A on Turbo Air Pumps, also copy of our widely used "Steam Tables for Condenser Work."

Wheeler Condenser & Engineering Co.

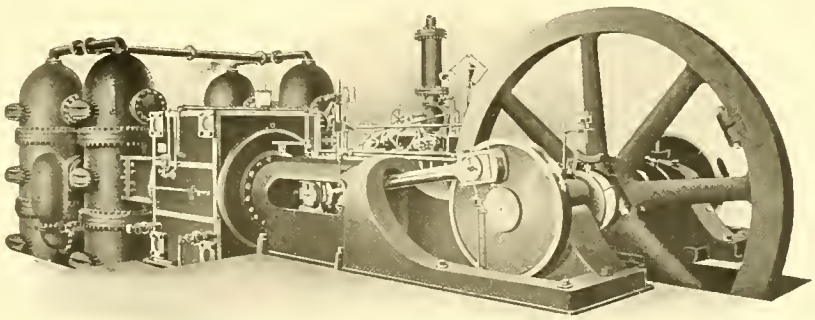
The Pioneer American Condenser Builder

Carteret, N. J.

HAMILTON CORLISS

Horizontal Crank and Fly Wheel Pumping Engines

are particularly designed for hard service and long life and the valves are arranged in the annealed steel casting decks in such manner that the flow of water is not deflected in all directions, as is necessarily the case when the bee-hive or cage system is used.



Hamilton Corliss Engines are the most economical steam operated prime movers known and are sold on their operating record.

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THE HOOVEN, OWENS, RENTSCHLER CO.

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What the Extra Weight of Goulds Pumps Means to the Power Pump Buyer

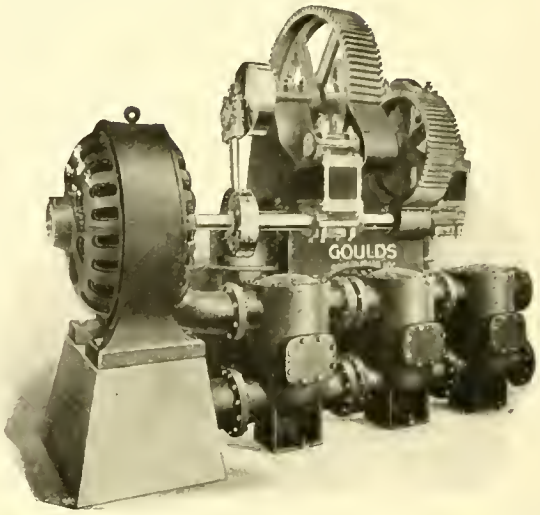
It means a massive, rigid frame which holds the working parts in perfect alignment, insuring smooth operation and long life.

It means large bearings which are durable and hold the shafts and gears true, reducing friction losses, wear and noise to a minimum.

It means large valve boxes with large, smooth waterways and large valve area, insuring minimum slippage and maximum efficiency.

It means liberal design in every feature, the factor that produces the durability and low operating and maintenance costs of Goulds Pumps.

The Goulds line contains pumps for every service. Bulletins on any type on request.



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LARGEST MFR. OF PUMPS FOR EVERY SERVICE

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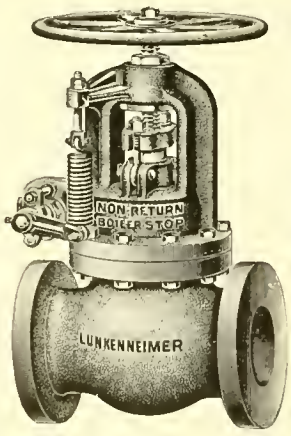
LUNKENHEIMER NON-RETURN SAFETY BOILER STOP VALVES



In any steam plant where two or more boilers are installed in battery, the outlet from each boiler where same is connected to the header should be provided with a **Lunkenheimer Non-return Safety Boiler Stop Valve.**

Should the pressure in one of the boilers suddenly decrease, caused by an accident, a **Lunkenheimer Non-return Safety Boiler Stop Valve** is guaranteed to close immediately and prevent the steam from the other boilers of the battery entering and discharging through the disabled one. Danger to life and property is greatly lessened, and as the plant can be operated with the other boiler, or boilers, without interference, considerable time and money are saved.

Lunkenheimer Non-return Safety Boiler Stop Valves are exceptionally strong, durable and reliable. All parts subjected to wear are renewable. Made in five different combinations of material to suit the requirements of various conditions of superheat and high pressure, and to meet the specifications of engineers who may differ as to what is best suited to the purpose.

Your local dealer can furnish them; if not, write us. Write for catalogue.

THE LUNKENHEIMER CO.

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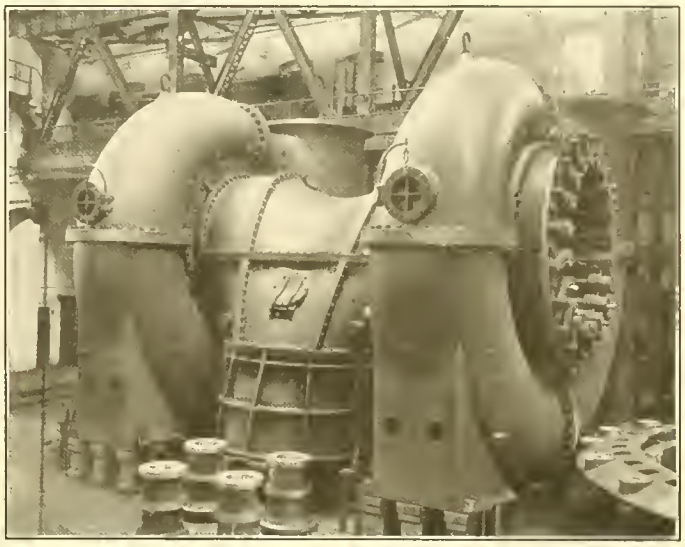
Specialists in the Design and Construction of High Class, High Power, and High Efficiency Hydraulic Turbines

The I. P. Morris Company in 1851 built its first hydraulic turbines, which were used continuously by the Water Works Department of Philadelphia until superseded by the present filtration system in 1908.

Total capacity of turbines built or under construction by I. P. Morris Company since it began active construction of hydraulic turbines now aggregate 1,645,000 horse-power.

Inquiries for turbines requiring special design will be given every attention.

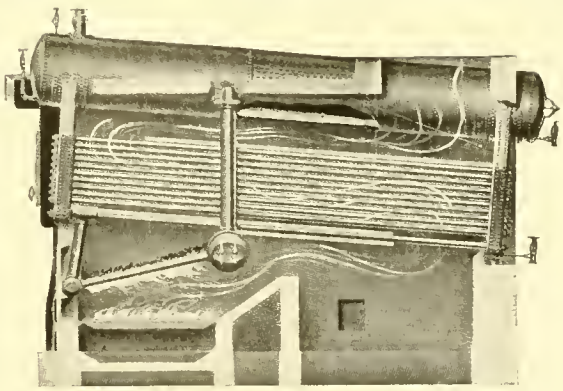


22,500 H. P. TURBINE

Two units furnished. Head 168 Feet. Speed 200 R. P. M.
Most Powerful Water Turbines in existence

Only Makers of "CUMBERLAND GROUND" Shafting
Large Stocks Quick Shipments

The O'Brien-Hawley Smokeless Down Draft Furnace

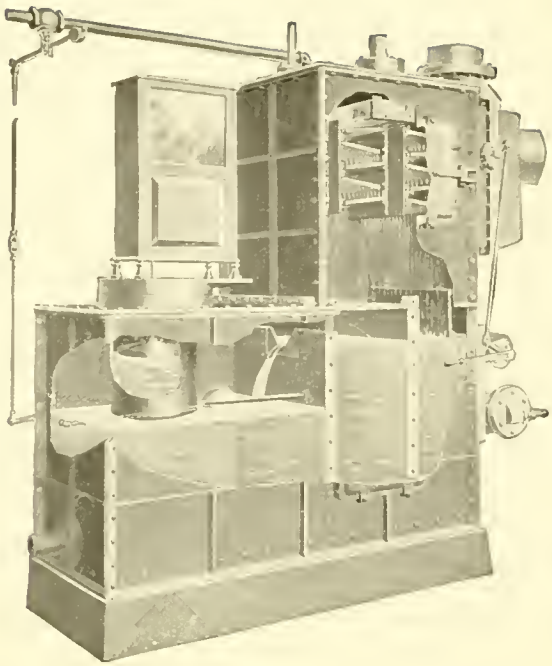


is constructed with two separate grates, one above the other. The upper grate is formed of a series of tubes opening at their ends into flanged steel manifolds through which the water of the boiler continually and rapidly circulates. The tubes form the fire grate. Air for combustion enters through fire doors near the top of the furnace. The division wall at the back of the furnace deflects the draft down through the fire upon the upper grate and over the fire on the lower grate. The fire on the lower grate is entirely fed by coked coal falling from the upper grate and the unconsumed gases and smoke from the upper fire are efficiently burned by the lower fire.

We obtained an efficiency of 72.4% on four 410 H. P. O'Brien boilers with down draft furnaces with coal containing 10720 B. T. U. in a test at the City Water Works, St. Louis, Mo.

We also manufacture horizontal tubular boilers, vertical water tube boilers, tanks, stacks, etc.

JOHN O'BRIEN BOILER WORKS COMPANY, 11th to 13th, Mullanphy to Howard ST. LOUIS, MO.



A Cash Register for the Coal Pile

The Cochrane Metering Heater, or the Cochrane Independent Meter for use with open or closed heaters, gives a receipt for every pound of water evaporated. **It enables you to determine how many pounds of steam you are getting per pound of coal,** what the best method of firing is, who is the best fireman, how much you gain by removing scale, blowing out soot, stopping up air leaks, etc. It gives your fire-room force an incentive to work to beat the record.

Cochrane Metering Heaters and Cochrane Independent Meters are being installed by the largest steam power plants all over the United States. Two recently shipped to the New York Edison Co. have a combined capacity of 1,200,000 lbs. of water per hour. Exhaustive tests made at our works demonstrate an accuracy within 1½% of absolute weight, which we guarantee.

If you are interested in boiler feed water or exhaust steam, or need a feed water heater, a feed water softener, a feed water meter or a steam or oil separator, write for our publications, particularly pamphlets on "Precision in the Measurement of Water" and "Feed Water Meters and their Practical Application."

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3199 N. 17th STREET PHILADELPHIA, PA.

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is a sincere effort to impress upon as many men as possible the opportunities that lie waiting for the increase of economy and efficiency in their equipment.

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—the natural outcome of an experience embracing many years in both the manufacture and economical adaptation of these products to a comprehensive variety of conditions.

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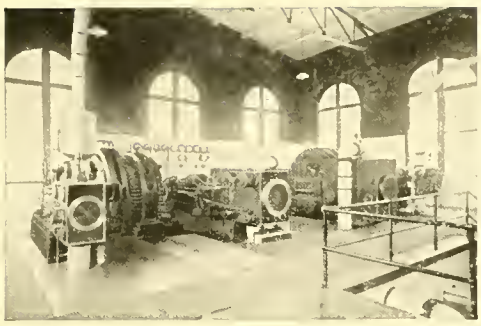
Makers of Goodrich Tires and Everything that's Best in Rubber



The Ball High Speed Corliss Engine

Has a Reputation

But when you buy a Ball you buy more than reputation. You buy superiority. You buy **durability and maintained economy.**

You buy that freedom from trouble that distinguishes a first-class machine from one that is built merely to sell.

Wise owners and managers no longer judge power plant machinery by its first cost.

Ultimate Economy is What Counts

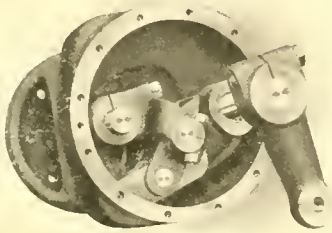
That is why so many of the most successful concerns in this country are using Ball Engines.

We would like to send you the new booklet giving a list of our Corliss installations, so that you may investigate some Ball Engines in your vicinity.

Write for it

BALL ENGINE CO.

ERIE PENN.

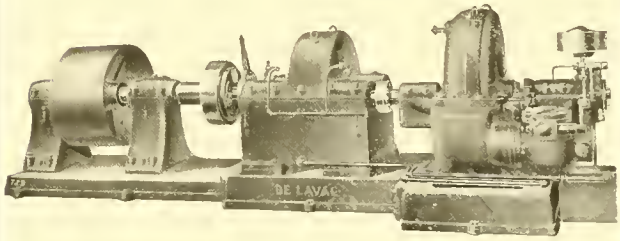


THE

DE LAVAL

Reduction Gear

Makes Steam Turbine Drive Universal



THE De Laval Heavy Duty Reduction Gear is a substantial, reliable piece of apparatus, which can be installed and will operate satisfactorily anywhere that a steam turbine would be installed, as for instance, driving low-head, large-capacity, condenser circulating pumps, direct current exciters, high duty centrifugal pumps for water works service, supplying power to factories by rope or belt drive (as when supplementing existing reciprocating engines by means of low-pressure or mixed-flow turbines), driving rolling mills, etc.

De Laval Class "A" Turbines are of the single-stage impulse type and are built in capacities of 7 to 600 H. P. (**Catalog "A-58"**). De Laval Class "C" Turbines are of the Velocity-stage type, ranging in capacity from 1 to 600 H. P. (**Catalog "C-58"**). De Laval Class "D" Pressure-stage Impulse Turbines or Multi-cellular turbines are built in capacities from 50 to 15,000 H. P. (**Catalog "D-58"**). Special and efficient turbines are built for back-pressure and bleeder service.

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Car Hauls
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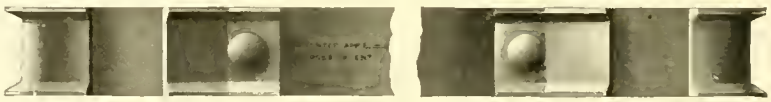
FAIRMONT Steel Ties

FAIRMONT STYLE "A" STEEL MINE TIE

"I have paid close attention to their use, their reliability and their condition after being used two or three times. They are savers of time, material and labor and make just as good track as could be made with wood ties." (Name and complete opinion, which was reached through the performance of Fairmont Steel Ties, sent on request.)



And we have the proof from many users of their advantages. Fairmont Steel Ties are true to gauge—the rail is securely held in place by means of a simple wooden wedge. Splice bars, bolts and spikes are eliminated—a saving on both material and labor. From 3 to 5 inches additional height above top of rail are gained—Fairmont Ties bring the rails down to the floor. **Bulletin and details of trial order sent on request.**

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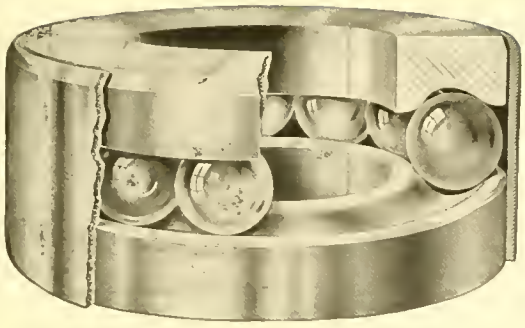

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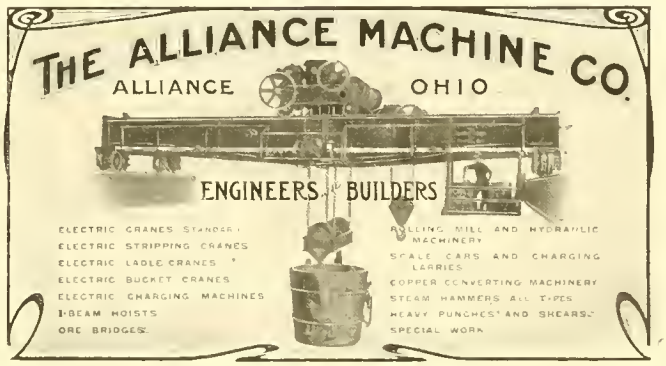

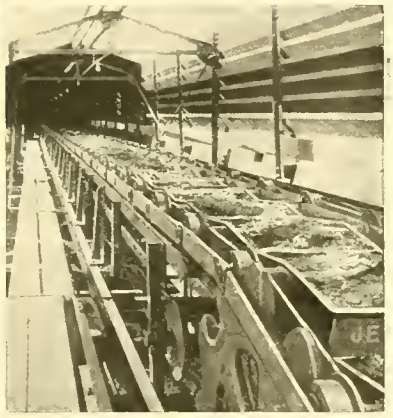

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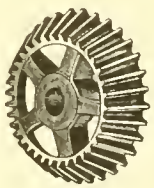

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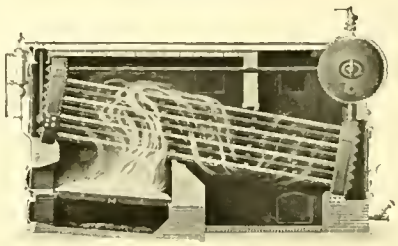

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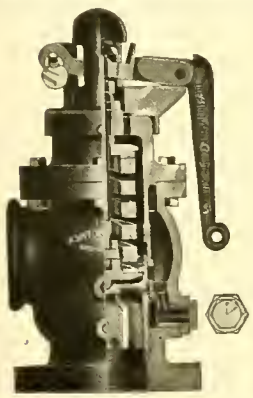

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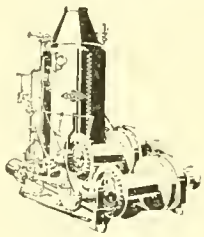

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Ratio 4:1 up to 1600:1 or more

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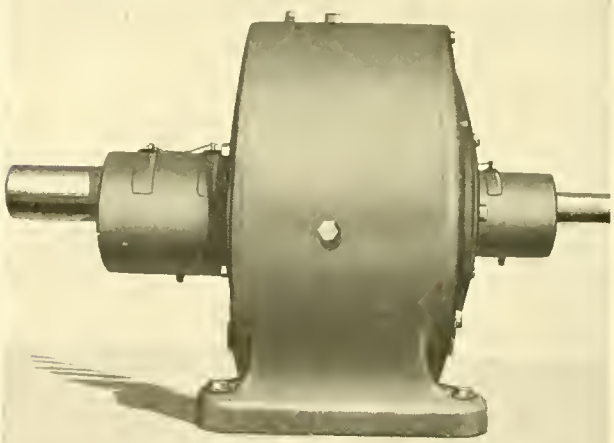

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Steam Turbines, single and multi-stage, for all services. Centrifugal Pumps, single and multi-stage, for all capacities and all heads. Centrifugal Blowers and Air Compressors, and special Centrifugal Apparatus. De Laval Speed-reduction Gears.

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Manufacturers of Hamilton Corliss Engines, Hamilton High Speed Corliss Engines, High Duty Pumping Engines, Power Pumps and Compressors, Special Heavy Castings.

See pages 6, 7, 309 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Compressors

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Water Tube, Internal Furnace and Return Tubular Boilers. Self-Supporting Stacks, Feed Water Heaters.

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Pressure and Recording Gauges, Engine Room Clocks and Counters for all purposes. Iron and Brass Pop Safety and Relief Valves for stationary, marine and locomotive use. The American Thompson Improved Indicator with new improved detent motion. The American Ideal Steam Trap.

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Lackawanna Sight Feed Lubricators and Automatic Grease Cups.

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Air Filters
Separators
Steam Traps

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Complete Condensing Plants for High Vacuum; Counter Current, Jet and Surface Condensers, Air Pumps, Pumping Outfits, Re-Cooling Plants. Oil, Air and Steam Separators. Combined Oil Separators and Heaters. Dry and Wet Air Filters. Air Extractors for Feed Water ("Airex"). Return and Vacuum Steam Traps.

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GREEN ENGINEERING CO.

Steger Building CHICAGO, ILL.

Green Chain Grate Stokers for free burning and coking bituminous coals. GECO Pneumatic Ash Handling Systems.

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Cochrane Feed Water Heaters, Cochrane Steam and Oil Separators, Sorge-Cochrane Hot Process Softening Systems, Cochrane Multiport Valves, Cochrane Metering Heaters.

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Works: HOMESTEAD, PA. PITTSBURG, PA.

Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most difficult service for water, air or steam. Valves unlike all others.

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Manufacturers of Regulating Valves for all pressures and for steam, air and water. The best and only absolutely noiseless Combination Back Pressure and Relief Valve. Pump Regulators, Separators, Steam Traps, Automatic Stop and Check Valves. Write for complete catalogue.

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Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

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Heat and Cold Insulating Materials. Headquarters for 85% Magnesia Asbestos and Brine Pipe Coverings, Asbestos Products, etc.

See page 138 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Blow-off Valves
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Manufacturers of genuine Ludlow Gate Valves for all purposes. Special Blow-off Valves. Check Valves. Foot Valves. Sluice Gates. Indicator Posts. Fire Hydrants.

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PAPERS PUBLISHED BY A. S. M. E.

No. 1214. Unnecessary Losses in Firing Fuel Coal: C. R. Weymouth, price $0.30; No. 1213. Fuel Economy Tests at a Large Oil Burning Electric Plant: C. R. Weymouth, price $0.20; No. 1165. The Rational Utilization of Low Grade Fuels in Gas Producers: F. E. Junge, price $0.40; No. 1245. Some Properties of Steam: R. C. H. Heck, price $0.10.

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Return, Non-Return, Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

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Automatic Furnace

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Governors for Steam Engines, Turbines, Gas Engines. Mechanical Control Power Regulation.

See page 131 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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111 BROADWAY NEW YORK

Superheaters

The Foster Patent Superheater saves feed water, condensing water, coal and boiler power.

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Lubricating Oils for Power Plants, Central Stations, Machine Shops, Foundries and all general purposes. All classes of Petroleum Products of the highest quality.

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Surface, Jet and Barometric Condensers, Combined Surface Condensers and Feed Water Heaters, Cooling Towers, Edwards Air Pumps, Centrifugal Pumps, Rotative Dry Vacuum Pumps and Multiple Effect and Evaporating Machinery.

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Manufacturers of High Vacuum Apparatus, Condensers, Air Pumps, Feed-Water Heaters, Water Cooling Towers, Boiler Feed and Pressure Pumps.

See page 65 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Pipe-Joint Clamps

YARNALL-WARING CO. CHESTNUT HILL PHILADELPHIA, PA.

Manufacturers of the "Lea" V-Notch Recording Meter, Simplex Seatless Blow-off Valve and the Simplex Pipe-Joint Clamp.

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Papers on Power Plant Specialties

PAPERS PUBLISHED BY A. S. M. E.

No. 1085. Performance of a Superheater: A. Bement, price $0.10; No. 1070. A Twist Drill Dynamometer: H. P. Fairfield, price $0.10; No. 921. The Bursting of Small Cast Iron Fly-Wheels: C. H. Benjamin, price $0.20; No. 1111. Balancing of Pumping Engines: A. F. Nagle, price $0.10.

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Auburn Four Point Contact Cone Principle Ball Thrust Bearings, Auburn Special Ball Thrust Bearings, Auburn Steel, Brass and Bronze Balls, Solid and Hollow.

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Pulleys
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THE A. & F. BROWN CO. 79 BARCLAY ST. NEW YORK

Manufacturers of Shafting, Pulleys, Hangers, etc., for Transmission of Power.

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Power Transmission
Elevators
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Manufacturers of everything for the Mechanical Transmission of Power; also Elevating and Conveying machinery, and the "Eureka" Water Softener. Our new catalog 106A11 gives an idea of the Dodge line.

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Friction Clutch Pulleys, Couplings, Quills, Operators, Clutch Sheaves, Floor Stands, Heavy Mill Bearings, Shaft Couplings, Sheaves and Tension Carriages, Pulleys and Fly Wheels.

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Power Transmission Appliances

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Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

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Rockwood Paper Frictions have proven their unquestioned superiority. You will find our booklets regarding Transmission of Power by Belts and Friction Transmission desirable additions to your engineering library.

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Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments

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Power Transmission

PAPERS PUBLISHED BY A. S. M. E.

No. 1276. Symposium on Electric Driving in Machine Shop: A. L. DeLeeuw, C. Robbins, J. Riddell and discussion, price $1.10; No. 1335. Variable-speed Power Transmission: G. H. Barrus and C. M. Menly, price $0.10; No. S 47 X. A New Theory of Belt Driving: S. Haar, price $0.20; No. 1230. Transmission of Power by Leather Belting: C. G. Barth, price $0.50.

Papers on Power Transmission

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Makers of Alliance Cranes of all types; also Rolling Mill and Hydraulic Machinery, Steam Hammers, Punches and Shears, Scale Cars, Copper-Converting Machinery, etc.

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Electric and Hand Power Cranes, Portable Electric and Monorail Hoists, Complete Track Systems.

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Elevating, Conveying and Power Transmitting Machinery. Helicoid and screw conveyors, machine molded gears, pulleys, fly-wheels, rope sheaves and drives, sprocket wheels and chain, buckets, belting, shafting and bearings.

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Hoisting Engines and Derricks. All sizes and types of engines.

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Manufacturers of Electric and Belt Power Passenger and Freight Elevators, Hoisting Machines, Friction Winding Drums, Friction Clutches and Friction Clutch Pulleys.

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Manufacturers of Goodrich Conveyor Belt. The Goodrich "Longlife" "Maxecon" and "Grainbelt" Conveyors will handle more tons per dollar of cost than any other belt made.

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Hoisting Engines—steam and electric, for every use of the contractor, miner, warehouseman, railroads, shipowners, etc. Derricks, Derrick Irons and Derrick Hoists, Cableways for hoisting and conveying, Marine Transfer for coal and cargo handling.

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Elevators and Conveyors for every purpose; all accessories; Power Transmission Machinery.

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Manufacturers of Gravity Carriers, Conveyers, Spirals, Chutes, and Automatic Elevators. Engineering Department at your service.

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Manufacturers of Iron, Steel and Copper Wire Rope, and Wire of every description.

See page 185 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Electric Travelers for all purposes. Gantries. Wharf Cranes. Railroad Wrecking Cranes. Mono-Rail Systems. Electric Motor Controllers.

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Squeezing Machines, Hand or Power
Jolt Ramming Machines, Pneumatic or Electric
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Pneumatic Vibrators

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No. 868. Some Landmarks in the History of the Rolling Mill: C. H. Morgan, price $0.20; No. 1319. Pressure Recording Indicator for Punching Machinery: C. C. Anthony, price $0.10; No. 1322. Power Forging, with special Reference to Steam Hydraulic Forging Presses: B. Gerdau and G. Mesta, price $0.10.

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Contractors, Builders and Designers of Special Machinery.

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Portable Electric Tools for Drilling, Reaming, Tapping, Grinding and Slotting.

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Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

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Manufacturers of the Hartness Flat Turret Lathe; made in two sizes for both bar and chuck work.

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Single-Phase Motors. Polyphase Motors. Transformers, Power and Pole Type. Instruments, a complete line. A. C. Generators. Converters for charging vehicle batteries from A. C. Rectifiers for charging small storage batteries from A. C. Train Lighting (Electric) Equipments. Automobile Self Starters (Electric), etc.

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Twenty standard Air Compressor types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, ½ to 5 tons capacity; "Crown" Sand Rammers, floor and bench types.

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Papers on Air Compressors and Pneumatic Tools

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Vacuum Pumps and Condensers

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Positive Pressure Blowers for foundries. High Pressure Blowers. Blowers for vacuum cleaning, for laundries, for blacksmiths. Positive Rotary Pumps. Positive Pressure Gas Exhausters. High Pressure Gas Pumps. Flexible Couplings.

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Pumps

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Dryers. Direct heat, Indirect heat, and Steam Dryers for all kinds of materials.

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We make equipment to force or exhaust air under all conditions. Largest standard line of "ready to deliver" Fans in the world and special work done where necessary. Consulting representatives in or near your city.

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Economizers

Engines

PUMPS AND HYDRAULIC TURBINES

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High grade economical Pumps for all services. Surface and Jet Condensers.

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Manufacturers of Efficient Triplex Power Pumps for general water supply, municipal water-works, fire protection, hydraulic elevators, paper and pulp mills, boiler feed pumps, chemical pumps and air compressors, rotary, centrifugal and well pumps and hand pumps of every kind.

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Pumps

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Water Wheels with Connections and Complete Power Transmission, Water Wheel Governors, Gearing, Wood Pulp and Paper Machinery, Pumps, Hydraulic Presses. Special Machinery to order.

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McCormick Holyoke Turbines designed to suit Mill or Hydro-Electric Work. Paper Mill Machinery, Shafting, Gearing, Pulleys and Freight Elevators.

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Engineers and Machinists.
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Specialists in the design and construction of high class, high efficiency Hydraulic Turbines.
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Engines

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Manufacturers of Centrifugal Pumping Machinery, Vertical and Horizontal Engines and Marine Engines.
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Papers on Pumps and Hydraulic Turbines

PAPERS PUBLISHED BY A. S. M. E.

No. 381. Standard Method of Conducting Duty Trials of Pumping Engines; Committee Report, price $0.30; No. 1144. Balancing of Pumping Engines: A. S. Nagle, price $0.10; No. 1110. Development of Water-wheel Governor: M. A. Replogle, price $0.20; No. 1113. Turbine Design as Modified for Close Regulation: G. A. Bovinger, price $0.10.

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Aluminum Ingot, Sheet, Rod, Wire, Cable, Tubing and other forms.
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Our methods and processes for producing Die-Castings are generally conceded to be the most reliable and efficient known. Send for our latest booklet "Successful Die Casting."

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Sectional Cast Iron Water Tube and Return Flue Boilers. Also Direct and Indirect Radiators for Steam and Water Warming.
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Makers of Cyclometers, Odometers, Tachodometers, Tachometers, Counters and Fine Die Castings.
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For announcements or information, address

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OF

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FEBRUARY · 1914

INCLUDING THE TRANSACTIONS OF THE SOCIETY

The Society of the Industries

RECOGNIZING the extent to which industrial expansion has increased the field of the mechanical engineer, the Council has authorized the appointment of sub-committees for each industry and branch of engineering. Of the thirty-eight committees contemplated, twelve have been appointed and are actively at work.

It is proposed to have each committee consist of men recognized as leading authorities in their subject, without regard to Society membership, carefully selected to cover the different sections of the country and all phases of the subject.

TENTATIVE LIST OF COMMITTEES

* 1 Textiles
2 Paper and Wood Pulp
3 Sugar
* 4 Cement
5 Glass
6 Clay Products
7 Leather and Leather Products
8 Lumber and Wood Products
9 Metals and Metallurgical Machinery
10 Foundry
*11 Machine Shop
12 Agricultural Machinery and Implements
13 Mining and Ore Dressing Machinery
14 Excavating and Dredging
*15 Hoisting and Conveying
16 Road Transportation
17 Marine Transportation
*18 Rail Transportation
19 Steam Power and Plant Equipment
*20 Gas Power and Plant Equipment
21 Water Power and Plant Equipment
*22 Air Machinery
23 Pumping Machinery
24 Electrical Machinery
25 Heating and Ventilation
26 Refrigeration and Ice Making
27 Ordnance and Fire Arms
*28 Industrial Buildings
*29 Fire Protection
30 Protection of Industrial Workers
*31 Administration of Industrial Establishments
*32 Depreciation and Obsolescence
33 Relations with Architects
34 Relations with Metallurgists
35 Relations with Civil Engineers
36 Relations with Mining Engineers
37 Relations with Chemical Engineers
38 Relations with Electrical Engineers

*Already Appointed

The interest and coöperation of all engineers are desired in the work of these committees. Those who can assist in the work already under way or are interested in the formation of other committees are urged to communicate with the Society.

Total Membership of the Society, January 15, 1914 5,405

Net Increase in Membership Since December 15, 1913 138

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

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COMING MEETINGS OF THE SOCIETY

February 4, *Boston, Mass.* Subject: Railroad Rolling Stock, Electrical Equipment and Permanent Way, recent developments and present tendencies: Papers by Henry Bartlett, Frederic B. Hall, A. B. Corthell.

February 4, *St. Louis, Mo.*, Engineers Club. Meeting of the Associated Engineering Societies under the auspices of the St. Louis Section. Paper: Air Conditioning, by J. I. Lyle.

February 9, *Philadelphia, Pa.* Subject: Business Training for the Engineer. Discussion by Alex. C. Humphreys, Past-President, Theodore I. Jones and Ralph D. Mershon.

February 10, *New York City*, Engineering Societies Building. Under the auspices of the Sub-Committee on Railroads and the Committee on Meetings in New York. Paper: Brake Performance on Modern Steam Railroad Passenger Trains: A discussion of the results of the Pennsylvania Railroad Brake Tests of 1913, by S. W. Dudley, assistant chief engineer, Westinghouse Air Brake Company, Pittsburgh, Pa.

February 10, *San Francisco, Cal.* Subjects: Transportation of Crude Oil in Pipe Lines; and Proposed Modifications in the Regulations Governing Boiler Tests Where Crude Oil is Used for Fuel.

February 12, *Cincinnati, Ohio*, Engineers Club. Paper: Air Conditioning, by J. I. Lyle. Illustrated by lantern slides.

February 14, *Milwaukee, Wis.* Paper: The Newer Types of High Reduction Gears, Percy C. Day.

Spring Meeting, June 16-19, *St. Paul-Minneapolis.* See pp. iii and iv.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 FEBRUARY 1914 Number 2

BINDING THE JOURNAL

At the end of the year an index will be issued to those sections of The Journal containing the Transactions and the review of periodicals, with directions for binding, and members may follow any one of four plans as best suits their taste:

(1) Covers of a standard design will be supplied to members by the Society for use by a local binder, at the rate of $1.25 for half morocco, and 75 cents for buckram, prepaid.

(2) The Journal may be bound by a local binder, using such a cover as the individual member may desire.

(3) If copies of The Journal are sent to the Society, prepaid, the Transactions and the review sections will be bound and returned prepaid, at the rate of $2.25 for half morocco and $1.25 for buckram.

(4) The Society will have a limited reserve stock of printed sheets and can sell bound copies to members outright, at the rate of $4.00 for half morocco and $3.00 for buckram. As the reserve supply is not large, *it is imperative that members wishing to follow this plan should inform the Secretary at once.*

Prices to members abroad will be as above, with additional charge for carriage if such is necessary.

The volume of Transactions will be issued in its old form this year as usual and will contain papers and discussion given during the year 1913. This will be Volume 35 of Transactions and following its publication a complete index of the series, including Volumes 1 to 35, will be printed.

It is intended that Volume 35 of Transactions, to be published this year, shall be the last of the old series, and that dependence shall thereafter be placed upon The Journal for the records as well as for the news of the Society.

The Journal in its new form contains a complete record of the Society's activities, and every member who desires to have such a record in his own library should preserve his copies for binding. The Journal will contain a much more thorough presentation of the technical matter given at the meetings of the Society than could heretofore be included either in The Journal or Transactions, or in both combined. Owing to the necessity for limiting Transactions to a single volume annually, it has recently been possible to include in it only the papers and discussions presented at the Annual and Spring Meetings.

Under the new plan of publication, there will be included, in permanent form for binding, not only the papers and discussion of the Annual and Spring Meetings, but reports of the meetings held by the local sections now organized in twelve cities; and in addition, the review of engineering literature, compiled from the publications which come to the Engineering Societies library, from every part of the world. This section contains the Foreign Review, which has been so favorably received, augmented by a review of the publications of engineering societies in different countries.

In other words, under the present plan it is proposed to concentrate on The Journal and thereby give to the membership a vastly improved service, in accord with the needs of a rapidly growing engineering society. Such a development, however, can be carried out only by an avoidance of the wasteful and expensive duplication of printed matter in The Journal and in the annual volume of Transactions.

This is one of the important considerations which has led the Council and Publication Committee to combine Transactions and The Journal.

SPRING MEETING

The local committee in St. Paul and Minneapolis have been advancing the preparations for the coming Spring Meeting, to be held in these cities from June 16 to 19, and have tentatively arranged a program with provision for the entertainment of their guests and with opportunities for inspection of the many engineering features of that part of the Northwest. The Committee on Meetings have also mapped out the professional sessions for this meeting, the subjects for which are announced in this issue. The program as arranged follows:

TENTATIVE PROGRAM

Tuesday, June 16—St. Paul

Opening of headquarters, registration and acquaintanceship.

8.30 p.m. Reception.

9.30 p.m. Introductory remarks by James Hartness, President of the Society, followed by a message to the Engineering Fraternity, especially the mechanical engineering profession, by Mr. James J. Hill, former president of the Great Northern System.

10.00 p.m. Dancing.

Wednesday, June 17—St. Paul

10.00 a.m. Business meeting and professional session.

During the morning the ladies will be shown about the city and will be entertained at luncheon.

Wednesday Afternoon

The afternoon will be devoted to a second professional session.

Thursday, June 18—Minneapolis

9.15 a.m. Leave for Minneapolis by trolley.

10.00 a.m. Meeting at the University of Minnesota, Minneapolis. Address by Dr. George Vincent, president of the University.

12.00 m. Luncheon at the University Building.

During the morning the ladies will be shown about the city in automobiles.

Thursday Afternoon

The members of the Society and their guests will be entertained at the home of Mr. Gebhard Bohn on Lake Minnetonka. Mr. Bohn has a beautiful home with about twenty acres of ground, constituting the most attractive spot on the lake. Supper will be served and dancing will follow, either here or at the Minnetonka Club.

Friday, June 19—Duluth

Technical excursions. There is also a prospect of a trip to Duluth, in which case it is recommended that the party leave at 2.30 p.m., arriving in Duluth at 7.00 p.m., where they will be received by local members of the Society and will be given an opportunity the next day to look over the Duluth harbor with all its engineering features. It is hoped that boat connections will be such that members from the East can return via the Lakes.

A further suggestion is a trip to Keokuk to inspect the great water power plant on the Mississippi River.

PAPERS FOR THE NEXT SPRING AND ANNUAL MEETINGS

It is proposed by the Committee on Meetings to hold three groups of professional sessions at the Spring Meeting at St. Paul and Minneapolis, June 16-19, these occurring as in the tentative program published this month, on Wednesday morning and afternoon, June 17, and Thursday morning, June 18. There will be an opportunity for simultaneous sessions during these periods, in so far as these seem necessary to cover the subjects offered for the various sub-committees.

It is expected that one session will be upon the subject of Grain Handling and Ore Handling, a topic of local interest for this meeting, and of great general interest as well. The subject is a large and important one, a thorough treatment of which should be on record in the Society's publications.

It is proposed to have one session devoted to papers on Powdered Fuel which it is hoped will bring out data upon the relative merits of powdered fuel and oil and gas fuel for different purposes in industrial work. Papers and discussion for this session are desired on four subjects, as follows: Powdered fuel in open-hearth furnaces; in cement kilns; for the generation of steam; and for industrial furnaces.

A third session will as usual be devoted to miscellaneous papers and it should here be noted that in case more papers are received on general subjects than can be assigned to a single session at the Spring Meeting, there may still be an opportunity to use some of them at least at local meetings of the Society, which are now regularly held in different cities throughout the country. Such papers are earnestly solicited, especially when giving the results of the individual work of members.

Supplementing these three main sessions, it is probable that there will be others arranged by sub-committees. There are already papers in prospect upon the Diesel engine for a Gas Power meeting.

It is requested that any who have papers or data to contribute for the Spring Meeting, however brief or extended they may be, will have their manuscript in the hands of the Committee by April 1.

Among important reports to come up at the Spring Meeting for discussion will be the preliminary report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for Care of Same in Service, and that of the Committee on Flanges, the latter of which was presented for preliminary discussion at the last Annual Meeting.

ANNUAL MEETING

A tentative schedule for the Annual Meeting to be held next December in New York has also been arranged, with five periods for professional sessions. The opening session, which will be the leading feature of the meeting, will be upon the general subject of the Engineer and Public Relations, taking up also questions of municipal engineering. Prominent engineers and officials in municipal work will be invited to participate.

A session will be devoted to Aviation, which has already aroused much interest from an engineering standpoint at local meetings held in the East. This has led to the belief that the engineer, through his knowledge of the fundamentals of mechanics and physics, has much to contribute to the development of this new science, and that he may be able to give some practical help to those who have been engaged in the conquest of the air.

Another important session will be devoted to En-

gineering Metals, in the production and use of which there have been marked advances during the past ten years. There will be four leading papers, as follows: Steels for Construction, Steels for Cutting Tools, Cast-Irons, Alloys of Copper, Tin and Aluminum. It is expected to have these papers issued several months in advance of the meeting, so that the subject can be fully discussed, thus crystallizing the work of advancement in the various fields and placing on record a synopsis of what has actually been accomplished.

At this meeting there will be two sessions for miscellaneous papers and probably other sessions contributed by the sub-committees. The Sub-Committee on Railroads has already announced its intention of participating.

There are also several important reports to come up for discussion which may in themselves require a session, among these being that on Power Tests, upon which the Committee has been working for a long period of time in an effort to standardize methods and adjust the various apparatus used in the generation of power.

FEBRUARY MEETING IN NEW YORK

The New York meeting for February will be held jointly by the Sub-Committee on Railroads and the Committee on Meetings of the Society in New York, on Tuesday evening, February 10, in the Engineering Societies Building. The paper will be by S. W. Dudley, assistant chief engineer of the Westinghouse Air Brake Company, of Pittsburgh, Pa., upon the air brake tests recently conducted on the Pennsylvania Railroad, with a discussion of important improvements in the braking of heavy passenger cars. These tests are the most elaborate brake tests ever conducted and constitute the most important recent contribution to the subject of air brakes. A train of 12 steel cars, with locomotive and equipment, and a corps of 40 observers, besides extended laboratory equipment, were required for the tests, which extended over a period of three months.

A train of 12 steel cars at 60 miles per hour stores up 224,000,000 ft-lb. of energy. This is sufficient to raise the entire train 120 ft. With prevailing brake equipment such a train would be stopped by an emergency application in a distance of 1600 to 2200 ft., according to the truck rigging and brake shoe design. The Pennsylvania Railroad tests showed that this distance can actually be reduced to 1000 ft., or to within the length of the train. This was the result of improvements in the truck brake design, involving the clasp brake having two shoes per wheel, and the location of the brake shoes with reference to the horizontal center line of the wheels, in addition to improved methods of applying the air brakes quickly and simultaneously and at a high pressure, through an electro-pneumatic control which has not only opened the way for securing the maximum effect in the operation of practically all the factors involved in air-brake apparatus, but has secured a remarkable improvement in flexibility, efficiency, and economy. Trains of fifteen years ago were stopped in about half the distance prevailing in the practice of today. Increased size and weight of equipment have brought about an entirely new brake problem which it was the purpose of these tests to solve.

CORRECTION

In the paper on Increase of Bore by Centrifugal Stresses, by Sanford A. Moss, published in Volume 34 of Transactions, in formula [7] on page 912, the quantity which now appears as r_1 should in each case read r_1^2.

LOCAL ORGANIZATIONS

A feature of local meetings in many of the cities where the Society is undertaking to get its members together is the coöperation existing between the membership of different engineering organizations. By this means, the engineers of a city are brought together, without regard to the particular society to which they belong, resulting in the broadening of acquaintanceship and a mutual helpfulness in advancing the cause of the engineer and in acquainting people generally with the important work which he is undertaking. A circular recently issued by the Engineers Society of Milwaukee is unique in the way in which it unites the organization of the various societies in that city under the common management of a central operative and business organization bearing the title of the Engineers Society of Milwaukee. The first page of the circular is worded as follows:

ENGINEERS SOCIETY OF MILWAUKEE

STOCKHOLDERS

So to say:

Local Members—

American Society Mechanical Engineers
American Institute Electrical Engineers
Verein Deutscher Ingenieure
American Society Civil Engineers
American Chemical Society
Other engineers and technical men in and around Milwaukee.

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Made up of representatives from each of the above National Societies

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All you can get out of it in the way of Social and Professional profit through the interchange of experience.

One mailing list for all, whether meetings are Sectional or General

No entrance fee required from members of a section.

NEW LIBRARY HOURS

Until April the Engineering Societies Library will remain open daily from 9 a. m. to 10 p. m., instead of until 9 p. m. as heretofore. This change is made for the greater convenience of readers using the library in the evening, who may not find it worth while to come to the building when the time is too short to accomplish any extensive reading. During the past year 12,000 visited the library, making an average of between 40 and 45 readers for each working day.

The library is open to the public each week-day, except Christmas, New Year's, Thanksgiving and Independence Days, with librarians in attendance.

A HIGHER STANDARD OF MEMBERSHIP

The revision of C9 and C11 of the Constitution relating to the membership grades, which has already come up for consideration at the past two meetings of the Society and has been put to letter ballot, raises the interesting question of the relative requirements for the grades affected by these changes in the leading engineering societies.

The proposed amendments raise the grades of Member and Associate-Member to a standard comparable with the highest of any of the societies. They make the following provisions:

C9 A member shall be an Engineer or Teacher of Applied Science of thirty-two years of age, or over, and shall have been in the active practice of his profession for at least ten years and in responsible charge of important work for five years, and shall be qualified to design as well as to direct engineering work. Fulfilling the duties of a Professor of Engineering who is in charge of a department in a college or school of accepted standing shall be taken as an equivalent to an equal number of years of active practice. Graduation from a school of engineering of recognized standing shall be considered as equivalent to two years of active practice.

C11 An Associate-Member shall be a professional engineer not less than twenty-seven years of age, who shall have been in the active practice of his profession for at least six years, and who shall have had responsible charge of work as principal or assistant for at least one year. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice.

If the proposed amendments receive the favorable vote of the members no applications will be accepted for action under the present requirements after March 20.

A comparison of the above with the following requirements will be of interest:

THE INSTITUTION OF CIVIL ENGINEERS OF GREAT BRITAIN

Member: 33 years old; further than the requirements for Associate-Member, five years employment in positions of responsibility for the design or execution of important engineering work, or suitable education and training as a civil engineer; and further at least 15 years employment in positions of responsibility.

Associate-Member: 25 years old; educated as a civil engineer and actually engaged in the design or construction of works comprised within the profession of a civil engineer.

THE INSTITUTION OF MECHANICAL ENGINEERS OF GREAT BRITAIN

Member: 30 years old; regularly trained as a mechanical engineer; engaged for a sufficient period in important position of independent responsibility in direction of engineering work.

Associate-Member: 25 years old; regularly trained as a mechanical engineer, with sufficient practical experience in the direction or design of engineering work. If over 30 years of age he must have further at least one year in responsible engineering position.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Member: 30 years old; a professional engineer, architect, or marine architect; in active practice of his profession for ten years; in responsible charge of work five years; qualified to design and to direct engineering works.

Associate-Member: 25 years old; in active practice of his profession six years; in responsible charge of work as principal or assistant one year.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Fellow (equivalent to Member, Am. Soc. M. E.): 32 years old; ability to design and take responsible charge of important electrical work; in active practice of his profession ten years and in responsible charge three years.

Member (equivalent to Associate-Member, Am. Soc. M. E.): 27 years old; electrical engineer by profession, in active practice in responsible work five years.

AMERICAN INSTITUTE OF MINING ENGINEERS

Member: all professional mining engineers, geologists, metallurgists, or chemists, and all persons actively engaged in mining and metallurgical engineering, geology or chemistry.

(No grade equivalent to Associate-Member grade of Am. Soc. M. E.)

COUNCIL NOTES

At the meeting of the Council on January 9 a report was received from the Joint Conference Committee, with resolutions covering a memorial presented by the American Institute of Consulting Engineers, urging the appointment of engineers as members of public service commissions. This report was referred to the Public Relations Committee.

The following Sub-Committee on Railroads was appointed: E. B. Katte, Chairman; G. M. Basford, W. G. Besler, F. H. Clark, A. H. Ehle, C. E. Eveleth, W. F. M. Goss, A. L. Humphreys, W. F. Kiesel, N. W. Storer, H. H. Vaughan, R. V. Wright.

The representatives of the national engineering societies, including the Society for the Promotion of Engineering Education, recently met with the representatives of the Carnegie Foundation for the Advancement of Teaching, and the latter will undertake to prepare a special report of the status of engineering education in America. It is proposed to engage the ablest available man to prepare this report, under the direction of Dr. Henry S. Pritchett, president of the Foundation.

CALVIN W. RICE, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i. e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are under twenty-five years of age and therefore qualified for Junior grade only. The Membership Committee and in turn the Council urge the members to assume their share of the responsibility of receiving these candidates into the membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before March 10, 1914.

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ADAMSON, KEITH F., Instr. in M.E., University of Penna., Philadelphia, Pa.

AMNEUS, NILES A., Mch. Designer, Bird & Son, East Walpole, Mass.

BELL, JAMES A., M.M., Illinois Steel Co., Joliet, Ill.

BJORK, CARL G., Mech. Draftsman and Designer, Stone & Webster Engrg. Corp., Boston, Mass.

BRADLEY, JOHN E., Pres., Osgood Bradley Car Co., Worcester, Mass.

BUENTING, OTTO W., Genl. Supt., Westinghouse Air Brake Co., Wilmerding, Pa.

BURNETT, R. W., Genl. Master Car Builder, Canadian Pacific Railway, Montreal, P. Q.

BUSE, F. W., Ch. Engr., Deutsche Maschinenfabrik A.G., Duisburg,—Office at 82 Beaver St., New York.

CALKINS, MARCUS E., Pres. and Genl. Mgr., Cayuga Lake Cement Co., Ithaca, N. Y.

CARLSON, CHARLES A., Genl. Draftsman, Deere & Co., Moline, Ill.

COE, RALPH T., Mgr., Canadian Sirocco Co., Ltd., Windsor, Ont., Canada.

CRAMER, ROBERT, Engr. & Designer, Motor Engrg. Co., Chicago, Ill.

CUMMISKEY, WM. M., Elec. Engr., Gurney Elec. Elev. Co., Honesdale, Pa.

DALLEY, A. H. CHAS., Mgr., Amer. Engrg. Co. of Phila., Chicago Office, Chicago, Ill.

DRESES, HENRY, Prop. and Mgr., Dreses Machine Tool Co., Cincinnati, Ohio

EVELETH, CHARLES E., Railway and Traction Engrg. Dept., General Elec. Co., Schenectady, N. Y.

FIELD, ALFRED F. JR., Asst. to Mgr., The Stanley Works, Bridgewater, Mass.

FORD, HENRY R., Vice-Pres., McCarthy Bros. & Ford, Buffalo, N. Y.

GIRL, CHRISTIAN, Pres. & Genl. Mgr., The Perfection Spring Co., Cleveland, Ohio

GISH, JAMES A., JR., Asst. Wks. Mgr., Bath Portland Cement Co., Bath, Pa.

GOSS, STANLEY T., Mch. & Automatic Dept., New Britain Mch. Co., New Britain, Conn.

GRISWOLD, F. M. Genl. Inspr., The Home Insurance Co., New York

HOFFMAN, WILLIAM A. Inspector of Boilers, Elevators and Smoke Abatement, City of St. Louis, Mo.

HOWELL, JOHN W., Engr., Edison Lamp Works of General Elec. Co., Harrison, N. J.

JOHNSON, CHARLES S., Engr., Marion Steam Shovel Co., Marion, Ohio.

LARMER, JAMES G., Asst. M.M., Homestake Mining Co., Lead, S. D.

LINSHEIMER, SIDNEY W., Vice-Pres. and Genl. Mgr., The Holly Sugar Co., Denver, Colo.

LOUDER, JAS. W., Supt., Nazareth Cement Co., Nazareth, Pa.

MCINTYRE, JAMES K., Mech. Engr. at Works, Alberger Pump & Condenser Co., Newburgh, N. Y.

MOSES, ASHLEIGH S., Ch. Engr., National Lead Co. and St. Louis Smelting & Refining Co., St. Louis, Mo.

NEWCOMER, GEORGE M., Vice-Pres., F. L. Smidth & Co., 50 Church St., New York

NEWTON, GUY D., Instructor, University of Missouri, Columbia, Mo.

PARKS, FREDERICK W., Pres., The G. M. Parks Co., Fitchburg, Mass.

PARKS, HOWARD M., Vice-Pres., The G. M. Parks Co., Fitchburg, Mass.

PAULEY, JAMES B., Mgr., European Purchasing, International Harvester Corp., Brussels, Belgium

PHILLIPS, CHARLES H., Designer of Special Automatic Machinery for Threading Bolts, Buffalo, N. Y.

PRATT, FREDERICK R., M.M and Ch. Engr., Berkshire Cotton Mfg. Co., Adams, Mass.

ROBERTSON, REUBEN B., Genl. Mgr., The Champion Fibre Co., Canton, N. C.

SEEKAMP, CONRAD F., with Otis Elevator Co., New York

STEPHENS, WILLIS C., Eastern Mgr., Rice & Adams, Buffalo, N. Y.

STORRS, LUCIUS S., Pres., Connecticut Co., New Haven, Conn.

SUMMERS, LEWIS E., Mgr., Chicago Pneumatic Tool Co., Detroit, Mich.

THOMPSON, DAVID P., Asst. Genl. Supt., Inland Steel Co., Indiana Harbor, Ind.

TOURJEE, WILLIAM O., Mech. Engr., W. A. Harris Steam Engine Co., Providence, R. I.

TRUSCOTT, HAROLD S., Factory Supt., Hawaiian Sugar Co., Ltd., Makaweli, Kanai, T. H.

VAN DEVENTER, JOHN H., Genl. Supt., Buffalo Forge Co., Buffalo, N. Y.

WELLS, WILLIAM H., Supt. and Mech. Engr., George W. Blabon Co., Nicetown, Philadelphia, Pa.

WHITLOW, JOSEPH A., Ch. Engr., Board of Education, St. Louis, Mo.

WILLETT, WALLACE, Engr., with Nicholas S. Hill, 100 William St., New York

ZIMMERMANN, WM. F., Vice-Pres., Pittsburgh Testing Laboratory, 50 Church St., New York.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BARNUM, C. LESLIE, Mech. Engr., J. B. King & Co., New Brighton, N. Y.

BUNTING, CHAS. A. Asst. Engr., Illinois Soldiers' and Sailors' Home, Quincy, Ill.
CYPHERS, JAMES F., Mech. Supt., Merck & Co., Rahway, N. J.
ESHERICK, JOSEPH, Mech. Engr., Yarnall-Waring Co., Philadelphia, Pa.
FERGUSON, JAS. W., Sales Engr., New Departure Mfg. Co., Hartford, Conn.
FORTMANN, EDWARD, Mech. Engr., New York Transit Co., Binghamton, N. Y.
HAGEN, HAROLD F., Engr., The Green Fuel Economizer Co., Beacon, N. Y.
HARPER, CHAS. W. Engr., Stanley McCormick School, Burnsville, N. C.
HESS, H. LAWRENCE, Supt., The Hess Steel Castings Co., Bridgeton, N. J.
KING, HAROLD M., Asst. Engr., General Electric Co., West Lynn, Mass.
LANGE, WALTER C., Asst. to Engr., Consolidated Gas Co. of N. Y., New York
LASAR, EDWARD G., Vice-Pres., Lasar Mfg. Co., St. Louis, Mo.
MCGALL, ALBERT, Secy., The Gillette Roller Bearing Co., Newark, N. J.
SAWERS, EDWARD H., Asst. Steam Engr., Lackawanna Steel Co., Lackawanna, N. Y.
SCHACHA, ARTHUR L., Mech. Draftsman, The Elwell-Parker Elec. Co., Cleveland, Ohio.
SCHALLER, HERMAN W., Draftsman, Aultman, Taylor Machinery Co., Mansfield, Ohio
SCHWENKER, ROBERT F., Managing Editor, The Gas Engine Magazine, Cincinnati, Ohio
THOMPSON, RALPH E., Factory Supt., Gillette Safety Razor Co., Boston, Mass.
TURNBULL, GEORGE B., Ch. Engr., Great Lakes Engrg. Works, Detroit, Mich.
WILMS, HERMANN, Designing Engr., Fulton Iron Works, St. Louis, Mo.
WILSON, THOMAS B., Steam Engrg. Dept., Cambria Steel Co., Johnstown, Pa.

FOR CONSIDERATION AS JUNIOR

ALLAN, JAMES R., Draftsman and Designer, International Harvester Co., Chicago, Ill.
DEMOREST, WM. J., Asst. Engr., International Gas Development Co., New York
GROVER, ATWOOD H., Ch. Draftsman, McKiernan-Terry Drill Co., Dover, N. J.
HARRIS, BENJAMIN, Draftsman, Newport News Shipbuilding & Drydock Co., Newport News, Va.
MORTON, HAROLD S., Combustion Specialist and Salesman, North Western Fuel Co., St. Paul, Minn.
NEWMAN, WILLIAM C., with General Electric Co., West Lynn, Mass.
PHELPS, CLEON E., Mech. Engr., American Steel & Wire Co., Worcester, Mass.
ROSE, DAVID, Draftsman, Duquesne Light Co., Pittsburgh, Pa.
ROVER, RICHARD H., Designer and Draftsman, Power Specialty Co., Dansville, N. Y.

TRANSFER FROM ASSOCIATE

FINK, EMIL C., Vice-Pres., International Motor Co., New York
KAUFMAN, EMANUEL, Metallurgist on Steel and Iron, Pittsburgh, Pa.

PROMOTION FROM JUNIOR

BLANCHARD, ROLLO K., Mech. Engr., Neptune Meter Co., New York
BROWN, EDWIN H., Engr. and Member of Firm, Hewitt & Brown, Minneapolis, Minn.
COON, THURLOW E., Mech. Engr., The Coon-DeVisser Co., Detroit, Mich.
FERGUSON, WM. C., Vice-Pres., Walla-Walla Iron Works, Walla-Walla, Wash.
HARDY, NORMAN G., M.M., Arizona Copper Co., Ltd., Clifton, Ariz.
HEY, HARRY A., Asst. to Secy., The American Society of Mechanical Engineers, New York

SUMMARY

New applications	80
Transfer from Associate	2
Promotion from Junior	6
Total	88

MEMORIAL TO SIR WILLIAM H. WHITE

A movement has been started at the instigation of the leading engineers of England to erect a suitable memorial to Sir William H. White, a former Honorary Member of the Society. Sir William was personally known and loved by a large number of members and was known to the profession at large through his keen interest in everything that pertained to it. He had served as president of a large proportion of the engineering organizations abroad and was an honorary member of practically all of them. He will be remembered by the public as the designer of the Lusitania and Mauretania. Sir William was not only an engineer of note but a man of great versatility with wide interests in many fields.

Those who may desire to participate in this memorial are requested to communicate with the Secretary.

90th ANNIVERSARY OF RENSSELAER POLYTECHNIC INSTITUTE

On February 6 the Rensselaer Polytechnic Institute of Troy will celebrate by a banquet at the Hotel Biltmore their 90th anniversary. The presidents of the national engineering societies will be the guests of honor, and addresses will be made by the following men of affairs upon the work of the engineer: Howard Elliott, of the New York, New Haven & Hartford Railroad; Samuel Insull, president of the Commonwealth Edison Company of Chicago; F. W. Whitridge, president of the Third Avenue Railway Company, of New York; George B. Cortelyou, former Secretary of the Treasury, and now president of the Consolidated Gas Company; and Palmer C. Ricketts, president of the Institute. To avoid disappointment all members of the Society are invited to conform promptly with the invitations which they have received, as the seats are limited.

MIDWINTER CONVENTION OF THE A. I. M. E.

The second midwinter convention of the American Institute of Mining Engineers will be held in the Engineering Societies Building, New York, February 25-27, 1914. The meeting is under the auspices of the Electric Power Committee.

The technical sessions will be held during the morning and afternoon of each day of the convention, and on Thursday evening there will be a meeting devoted to the International Electrical Congress and the Panama Exposition in San Francisco in 1915.

OPERATION OF LARGE BOILERS

NOTES ON THE FURTHER OPERATION OF LARGE BOILERS OF THE DETROIT EDISON COMPANY

BY J. W. PARKER, DETROIT, MICH.

Junior Member of the Society

AT the December 1911 meeting of the Society, Dr. D. S. Jacobus presented a paper[1] giving the results of the first performance tests on the 2365-h.p. Stirling boilers at the Delray generating plant of the Detroit Edison Company. At the time of his tests three of these boilers were in service, one having been run about 18 months and the others nine months. Since that time six more of the type have been installed at the rate of two a year, the last two in the autumn of 1913. It is the object of this paper to present some report of the everyday experience in operating all these boilers.

Reliability. That a boiler unit can be made so reliable that it may in this respect be classed with the turbo-generator, has been the experience with the nine boilers installed at Detroit. Table 1 shows the performance of six of these units during October, November and December of 1912. This period was selected as being the time when reliability was essential on account of the plant load conditions. The load curve of the plant shown in Fig. 2 is typical. At no time was it compulsory to put a boiler out of commission; at no time was any boiler out of commission during the peak load of the day, from four o'clock to six o'clock in the afternoon. Of the 215 hours the three Taylor stoker-fired boilers were taken out of commission, but 89 hours occurred during the five peak days of the week, Monday to Friday. This time was employed in cleaning furnaces, repairing stokers and inspecting tubes externally. The boilers themselves proved to be 100 per cent reliable.

Possible Cause of Trouble. The causes which might take boilers out of commission at times when they are needed for service, are being eliminated. There are three sources from which to expect trouble: (*a*) the boiler proper, (*b*) the furnace brickwork, and (*c*) the stoker.

(*a*) The boiler itself need be no hazard. Fittings and flanged joints, if properly watched and followed up, do not cause shutdowns. The same is true of the tubes, which are seamless. From October 15, 1912, to November 1, 1913, there have been but two tubes replaced in seven boilers whose average age is two years. One front tube was taken out after the discovery of a small bag next to the fire, which was found during a periodical external inspection of the front tubes during furnace repairs. The other tube was in the back row and was spoiled by a mishandled turbine tube cleaner. Its condition was discovered while the soot was being blown from the heating surfaces by hand blowers. However, the leak was very slight and the boiler was not cut out of service until night.

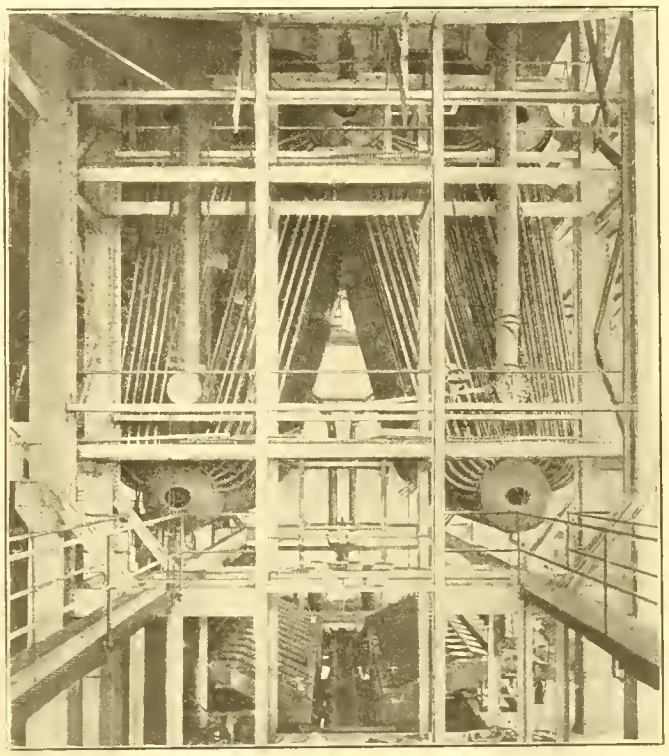


FIG. 1 GENERAL VIEW OF 2365-H.P. BOILER AND STOKER BEFORE BEING BRICKED UP

The plant is using about 8 per cent of make-up water, and although Detroit River water at Delray is not considered bad for boilers, nevertheless, a sulphate scale about 1/16 in. thick forms in the hot front tubes. These front surfaces are worked exceedingly hard and scale of even 1/16 in. thickness may make trouble. A soft piece of mud lodging on top of the hard scale is likely to cause a small bag. This trouble can occur only in the lower bends of the first row tubes, where loose dirt sometimes lodges.

Tube trouble will be practically eliminated by the use of pure water. The make-up water is now river water, treated with enough barium hydrate to neutralize the sulphate content. The percentage of make-up

[1] Trans. Am. Soc. M. E., vol. 33, p. 565

Presented at the Annual Meeting, December 1913, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

can be reduced to between 2 and 3 per cent by avoiding the necessity of blowing down boilers. It is seriously contemplated to use distilled water for make-up. There seems to be a lack of evidence that distilled water is of itself corrosive. The cost of distilling would be almost negligible, since the heat required to evaporate the raw water would be kept in the system by using

TABLE 1 SHOWING TIME BOILER UNITS WERE OUT OF COMMISSION

	Boilers Nos. 25, 27 and 33 Taylor Stoker		Boilers Nos. 26, 28 and 30 Roney Stoker	
	Hours	Per Cent	Hours	Per Cent
Total Number of Boiler-Hours (3 months)	5160	....	6624	....
Number of Boiler-Hours out of Service (cleaning)	298	....	323	....
Total Number of Boiler-Hours available for Service	4862	....	6301	....
Total Steaming Hours	3178	65.4	3594	57.0
Total Banking Hours	1469	30.2	1764	28.0
Out of Service at Night	26	0.5	....	....
Out of Service at Week End	100	2.1	219	3.5
Out of Service for Week-day Repairs	*89	1.8	†724	11.5
Total	4862	100.0	6301	100.0

* Cleaning Furnace, Inspecting Tubes and Repairing Stoker, 89 hours.

	Hours
† Repairing Stoker	537
Repairing Furnace Wall	173
Packing Blowoff Valves	14
Total	724

main turbine condensate for cooling water in the distillation process. To safeguard against any possible boiler corrosion, enough soft scale forming material would be introduced into the feedwater to cover the heating surfaces with a thin protecting scale.

(*b*) Furnace brickwork is with the underfeed stoker reduced to a minimum as evidenced by Fig. 3. It consists of the four furnace walls and nothing more. Much work has been done to make these walls stand up. It has been necessitated on the ground of maintenance cost only, however, since if certain sections of the furnace are rebuilt once a year, there is no chance for sudden trouble which would cause a shutdown. There has been no such sudden trouble.

(*c*) The stoker remains to be considered. The fallibility of the stoker is not great. Repairs ordinarily made are the replacement of tuyeres, dump plates and the like which have burned out. The work, mentioned in later paragraphs of this paper, which has been done to decrease stoker maintenance costs has, as in the case of brickwork, made it unlikely that the boiler need ever be taken out of commission for this cause, except when the plant load conditions permit it.

There have been cases of sudden stoker breakdown, sometimes occasioned by the introduction of chunks of iron or wood into the stoker rams, along with the coal. Also, there have occurred once or twice, serious burnouts of tuyeres and other grate surfaces extending over an area of 5 or 6 sq. ft. In these instances, the fire can be, and has been, banked on the one side of the furnace where the trouble exists and the other half of the furnace operated to get half capacity from the boiler. This one-side firing is entirely practicable.

To sum up, the experience has been this: the boilers were ready for service 95 per cent of the time considered; they were ready 98 per cent of the five full load days of the week; and ready for service 100 per cent of the time during the peak load periods. It is to be assumed that the boilers must be down for ten days or two weeks at nine or ten month intervals for boiler

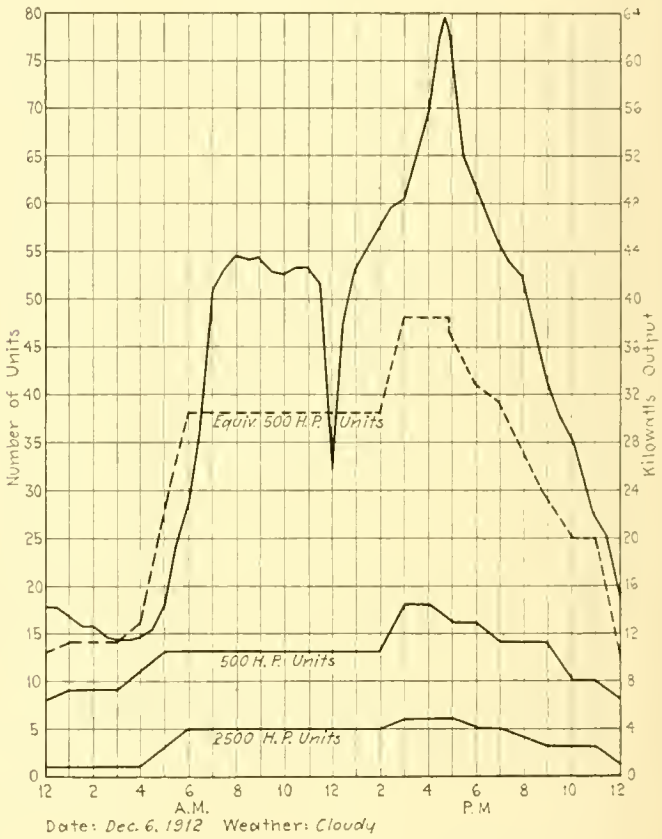


Fig. 2 Peak Load Curve, December 6, 1912

cleaning and a general overhauling of stokers and brickwork.

Recent Design. On the above considerations, the Detroit Edison Company is now building a power plant to contain six 20,000-kw. turbines served by 12 of these 2365-h.p. boilers, which is two boilers to one turbine, with no spares, or 10,000 kw. per boiler. Although the chances of losing the capacity of any boiler by a forced shutdown are remote, they have nevertheless been considered. At normal full load on a given turbine unit, the two boilers will operate at approxi-

mately 191 per cent of the builder's rating based on 10 sq. ft. of heating surface per boiler horsepower. If, with six boilers running at this rating, one boiler should go completely out of commission, the other five would have to carry the entire load of 60,000 kw. and thus operate at 235 per cent of rating, which is perfectly possible. As a matter of fact, the settings and auxiliaries are being designed to allow of continuous operation at 255 per cent of rating, which would enable three boilers to take the full load of four, i. e. 40,000 kw. Very recently, one of the Delray boilers was isolated from the rest of the plant with a 15,000 kw., seven-stage Curtis vertical turbine, and over 11,000 kw. was carried for an hour without difficulty.

Flexibility. The over-all boiler and furnace efficiency of the Taylor stoker-fired unit tested by Dr. Jacobus is shown by Fig. 4. The curve is a straight line throughout the range tested, having a gradual slope from 80 per cent efficiency at 93 per cent of rating, to 76 per cent efficiency at 214 per cent of rating. It is economical, therefore, to run as many boilers as possible at about 90 per cent of rating when the plant load is light, and then carry the peak of the load by increasing the rating on the boilers. This is our present practice. In this way, from morning till night there need be no fires banked or broken out of bank, and the firemen can bend their energies instead to manipulating their fires to the best advantage.

This flexibility is at no time more convenient than in summer when provision must be made for a sudden peak load due to a thunderstorm. At Delray, in the summer of 1914 the average day load will be about 63,000 kw., while provision must be made for a storm load of about 82,000 kw., a 30 per cent increase. Boilers ordinarily running at 100 per cent or 125 per cent of rating (a very economical point) will take a 30 per cent increase in load with very little effort. No banked fires will be carried during the daytime.

Control Methods. A boiler of such output assumes enough of importance and individuality, so to speak, in a 120,000-kw. plant to gain for itself unusual attention from the man who is firing it. One fireman fires two units. The control of each unit is brought directly under his hand in every way possible, so that a minimum of time will be wasted in mechanical manipulation. Fig. 5 is a view of the gage board and control point for one boiler. A water tender stationed on a gallery at the top drum level feeds the boiler but the fireman does everything else in the way of operating. The boiler dampers are shifted at the control point, and the throttles of the blower turbines are extended through the floor, the valve stand being seen in the view, near the gage board. The stokers are motor driven and one of the controllers is located on a steel column 6 ft. away from the gage board; the other could have been brought around also, but it was thought unnecessary, since a man must walk around to the stoker on the distant side to watch it and to study his fire. The control point of the opposite boiler is located just across the aisle from the first.

The plan is for one man to operate two stokers, and in addition, to have a head fireman in charge of from six to eight units, whose duty it is to oversee all the fires, and go to the assistance of any fireman who needs help. On the gage board are mounted steam gages showing pressure at the superheater inlet and superheater outlet and draft gages showing air pressure under the fire, draft at the damper, and draft at the top of the combustion chamber. There is also on this board the record dial of a CO meter. The meter itself

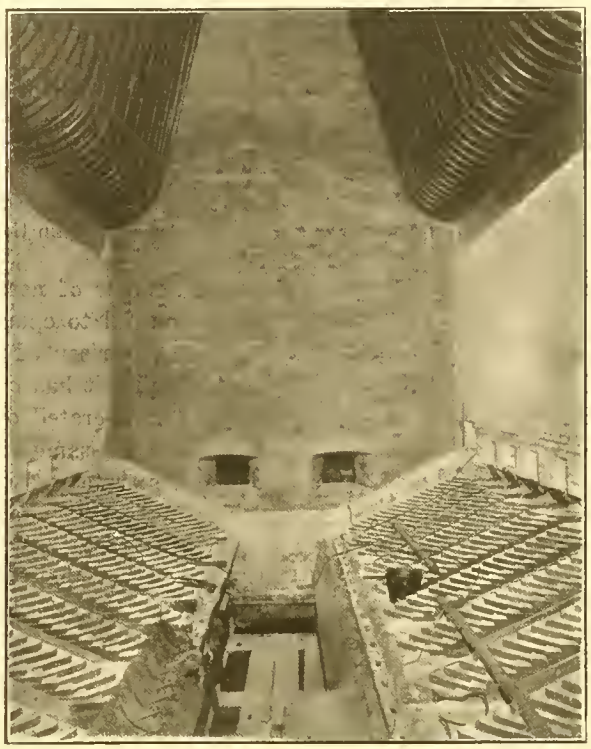


Fig. 3 Inside View of Furnace with Taylor Stoker

is mounted on a gallery 15 ft. above the boiler room in a position central of four boilers. Four samples of gas are drawn from one furnace, automatically mixed, and the resulting analysis is recorded where the fireman can watch it.

Fireroom Personnel. The whole idea is to employ the most expert firemen it is possible to develop, and give each man control of the burning of a very large amount of coal. It is economical to employ a fine type of man and pay him an expert's pay. The present first-class fireman's pay is 40 cents an hour and he is well treated as to vacation and sick leave. These men are given the benefit of whatever boiler testing is done, and a force of firemen is being built up that can obtain remarkable results with their fires. They are acquiring an intelligent working understanding of the combustion of coal. At the same time the unit cost of firing will be unusually low. The Table 2 is a schedule

of the labor necessary to handle 12 boilers of a six-turbine plant with no economizers installed.

The number of men allowed for such a plant is ample as shown by long experience at Delray. The cost per day is 55 per cent as much as the firing cost in a neighboring manufacturer's plant equipped with 24 278-h.p. Babcock & Wilcox boilers fired by overfeed stokers and equipped with economizers. In this plant it was found that maximum boiler and furnace efficiency was obtained while running the boilers at 95

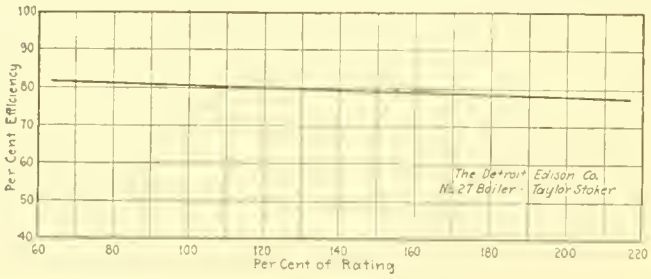


Fig. 4 Curve showing Over-All Efficiency of Boiler and Furnace at Different Ratings—Taylor-Stoker Fired Units

per cent of rating, and, with a load factor of nearly 100 per cent, it was considered economical to operate at that rating. In order to make a comparison of the cost of firing large units and small units, it has been assumed that the small boilers could be operated over the same range as the large ones. At the same time it has been assumed that both plants operate with the same load factor. The comparison is greatly in favor of the large unit, notwithstanding the fact that the scale of pay on these boilers is much higher than that on the 278-h.p. boilers. It is to be noted that the load factors are for monthly periods.

TABLE 2 LABOR COST OF FIRING A 12-BOILER PLANT

Maximum load..... 120,000 kw.		12 boilers at 191 per cent	
Minimum load..... 20,000 kw.		4 boilers at 96 per cent	
Monthly load factor (November).....			46 per cent
Operators employed—			
Morning shift	6.30- 2.30	2 head firemen at 45 cents .	$7.20
		6 firemen at 40 cents.....	19.20
		2 watertenders at 35 cents...	5.60
Afternoon shift	2.30-10.30	2 head firemen.....	7.20
		6 firemen.....	19.20
		2 watertenders.....	5.60
Night shift	10.30- 6.30	6 firemen.....	19.20
		1 watertender.....	2.80
			$86.00
Boiler room foremen.....			15.00
Total cost per day.....			$101.00
Cost of firing boilers—cents per kw.-hr.....			0.0076
Actual cost in a neighboring manufacturing plant's boiler room to generate an equal amount of energy but at 100 per cent load factor.....			$169.00
Estimated cost in neighboring manufacturing plant's boiler room if load factor is 46 per cent (allowing 191 per cent maximum boiler rating).....			$182.00
Scale of pay—watch foreman.....		31½	cents per hour
firemen.....		25	cents per hour

Pilot Steam Gage and Indicators. At the end of each firing aisle is mounted a large pilot steam gage. The dial is graduated in divisions of 1½ in. on its circumference but with no figures, and each scale division registers 1 lb. per sq. in. It is found and marked at just what point on this sensitive gage the boiler safety valves will lift and the steam pressure is carried accordingly. On the same gage board with the pilot gage are a clock and the dial of a load indicator, operated from the switchboard gallery, indicating the load on the entire plant in kilowatts. In handling his fires, the fireman is guided in the first place of course, by steam requirements as shown by the pilot gage and a steam flow meter. The air pressure under the fire and the stoker speed are controlled by hand.

Variable Stoker Speed. As before mentioned, the stokers are driven by motors. These are direct-current

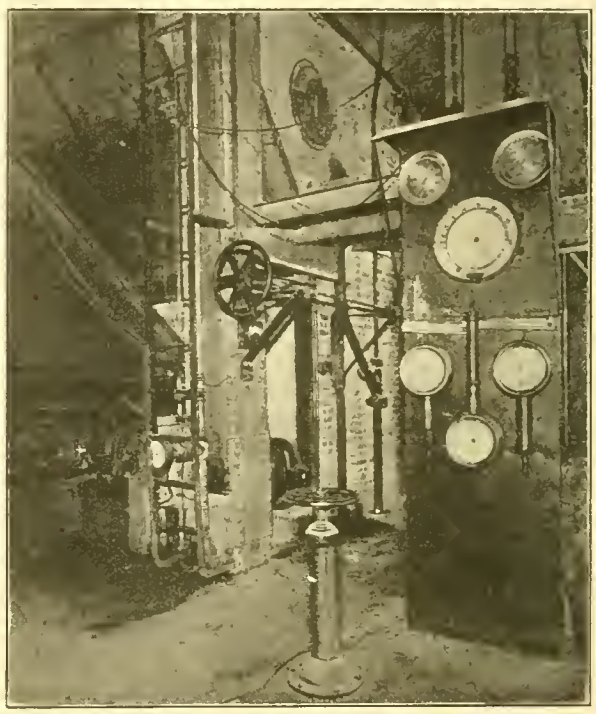


Fig. 5 Gage Board and Control Point for One Boiler Unit

interpole machines with a speed control by field resistance of four to one, and with 18 running points on the controllers. Indicating dial tachometers are being installed on the stoker shafts, so that the stoker speed for a given load may be watched carefully. An immense advantage is gained by being able to run the stoker at any given constant speed. The amount of power required to drive the stokers is extremely variable, and it is difficult to make a steam stoker engine govern under these conditions with a controlled range of speed variation of four to one.

As to furnace conditions, the firemen must judge by the CO_2 recorder, by the amount of air pressure necessary for any given boiler load, and by no means least of all by the color of the gases as they tumble over the

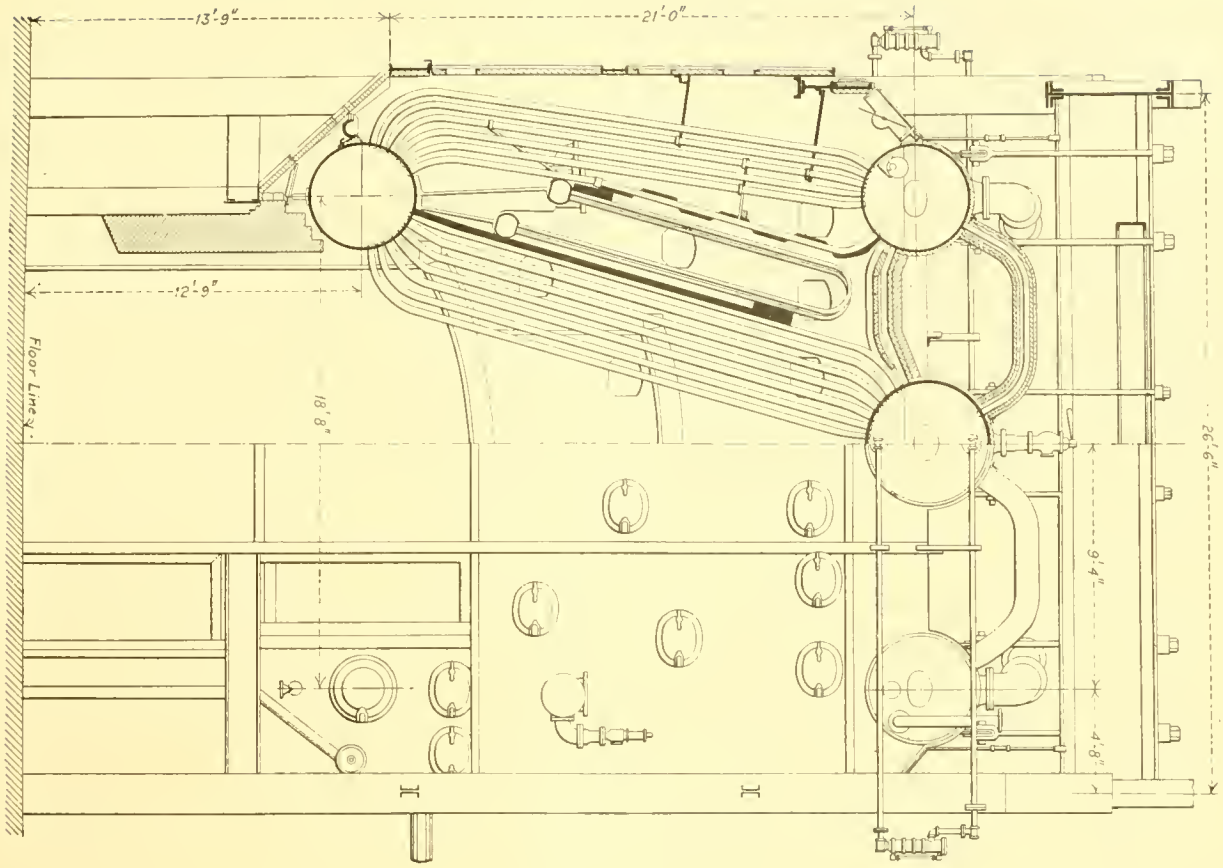


Fig. 6 End Section of Boiler showing Arrangement of Gas Passes

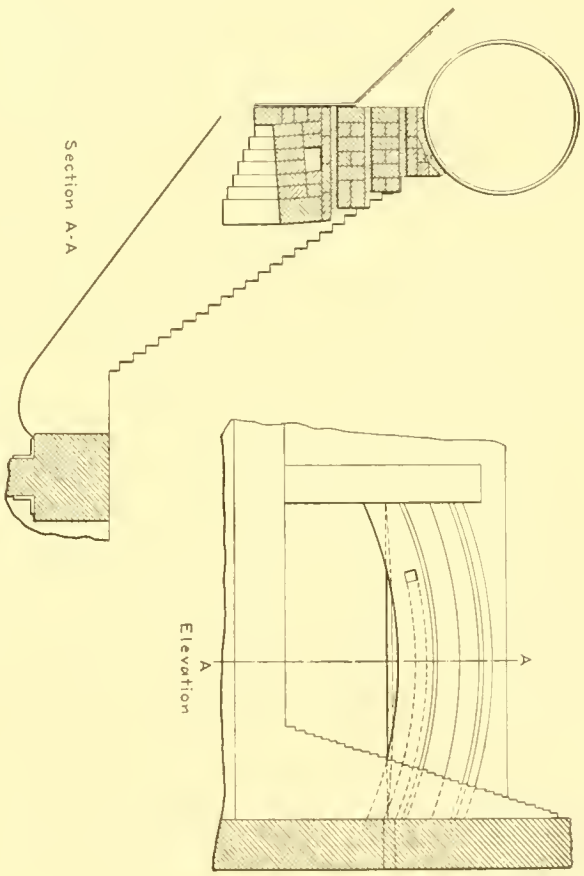


Fig. 7 Drawing of Arch for Roney Stoker

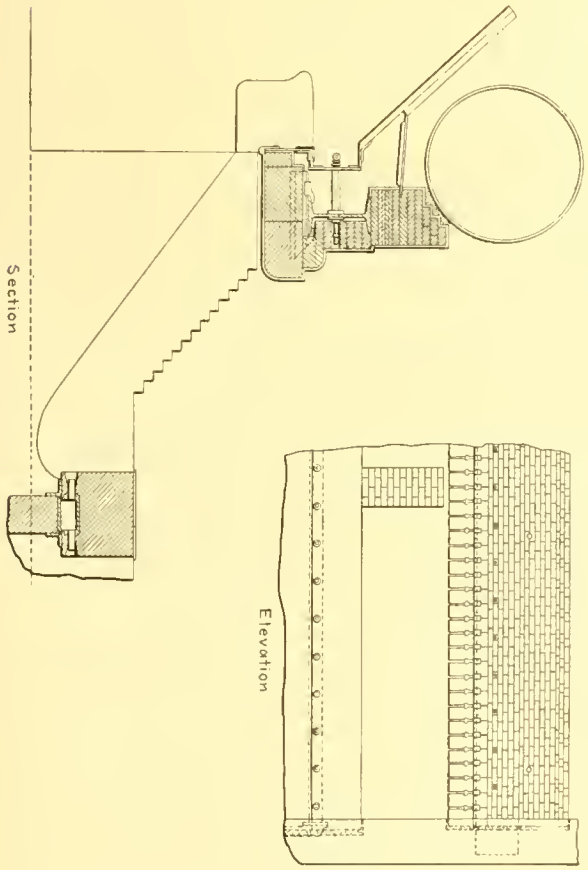


Fig. 8 Drawing of Flat Arch for Roney Stoker

first baffle and enter the top of the superheater pass, Fig 6. A reflecting observation device for this is at present being tried out, which allows the fireman to look into this boiler pass from a position near his gage board, instead of, as now, being dependent for this valuable indication on observation by the watertender or foreman.

Possibilities of Automatic Control. It is a question not yet entirely settled whether it would or would not be better to forsake hand control of these boilers for automatic control. It has been suggested that feedwater regulators be used and that some automatic steam pressure governed apparatus control the air pressure under the fire and the stoker speed. That is not necessitated by labor cost; neither by the need of

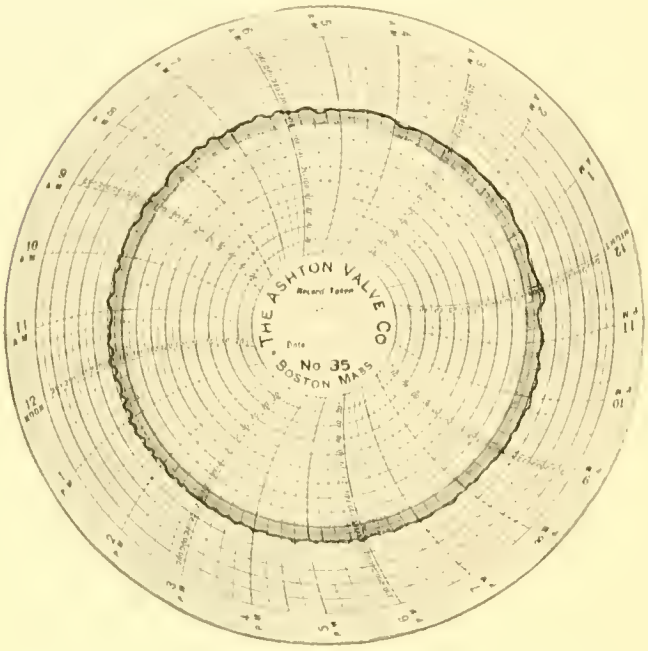


Fig. 9 Steam Pressure Chart, January 7, 1913

steam pressure regulation, as is evinced by the reproduction of the steam pressure chart in Fig. 9; this chart covers January 7, 1913, a day with wide variation of load. Our prejudice, if not our final judgment, is against automatic control.

As for feeding the boiler, a skillful water tender learns not to touch his feed valve except at rare intervals and when the load on the plant becomes steady, the steam flow is continuous also. One automatic feedwater regulator was experimented with. It was not a success, due in most part to a peculiarity of this type of boiler. On account of the rapid circulation, the water in the top middle drum stands at times as much as 2 ft., or more, higher than in the two outside drums, although the three are connected with water circulating tubes as well as by steam circulators and the main boiler tubes. The water columns are piped to the center drum, there being often no indication whatever of water in the outside drums.

The water level as shown in the glass under the above conditions, naturally, is variable, being a function of the rate of steaming. This being the case, it is easy for a feedwater regulator, automatically attempting to hold a constant level in the center drum, to get into difficulties whenever the demand for steam varies sharply, as it will, when the plant load is changing at noon or during the peak load of the day. When the steam demand decreases slightly, the water level may fall possibly an inch, being very sensitive. If the regulator immediately opens and starts feeding more heavily, the circulation will be still further decreased, and then the water level will fall lower and the regulator feed still more heavily. The steam output of the boiler will decrease rapidly with this, until the regulator begins to close again. The steam output will now begin to increase and the water level rise also and presently close the regulator entirely; a typical "hunting" action is thus set up. Some type of regulator can undoubtedly be worked out so as to handle these boilers: but it is questionable whether it would be worth while, when one water tender can tend water for a 60,000 kw. load.

Automatic Control of Fuel and Air. There remains the matter of handling coal and air feeds. In a small plant owned by the Detroit Edison Company, eight stokers are controlled automatically, both air and coal feed being independent of the fireman. The latter is not allowed to touch the stoker adjustments except to change the steam pressure one way or the other. This is going to the extreme, but it is not an uncommon method of firing underfeed stokers. It certainly does not tend to develop intelligent firemen nor obtain very satisfactory furnace efficiencies.

It is not desirable to substitute an automatic air and stoker control if a better CO_2 chart cannot be shown thereby. The danger is that the fireman will rely on the automatic device, rather than study conditions and control his fire intelligently. With the present hand control, excellent furnace conditions are being obtained and held. Observation of the furnace gases, as they enter the superheater pass from the top of the combustion chamber, shows that the combustion of volatile gases is entirely complete and that the operation is consequently smokeless. At the same time, the CO_2 charts show remarkably good results, 15 per cent of CO_2 being very common, the average being about 13.5 to 14 per cent. Repeated analyses made with an Orsat apparatus check these recording machines and at the same time discover no more than from a trace to 2/10 of a per cent of carbon monoxide.

Good conditions are most often disturbed by the periodic dumping of the ash and refuse from the stokers. There is now being tried out a continuous dumping device, a revolving grate, which bids to be very successful. It will undoubtedly go far toward

enabling the fireman to produce service results as good as those shown during tests.

Maintenance Costs. A careful study was made for four months in 1911 and 1912 of the maintenance costs of the boiler units fired by underfeed stokers and the figures are presented in Table 3. Since the period selected includes one job of general overhauling of a stoker and setting, it is conservative to estimate the maintenance cost for a whole year from these four months. This allows for the overhauling of boilers at intervals of eight months on the average, which is the present practice in the Delray plant. In this way the annual cost per kw.-hr. generated has been estimated, which includes maintenance of stokers, settings and boilers.

TABLE 3. MAINTENANCE COSTS OF TWO 2365-HP. BOILER UNITS WITH TAYLOR STOKERS.

INCLUDING REPAIRS TO BOILERS, STOKERS AND BRICKWORK

	Boiler No. 25	Boiler No. 27
December 1911—Hours steaming	442	447
Cost of material and labor	$116.00	$112.60
January 1912—Hours steaming	483	490
Cost of material and labor	$84.86	$2.88
February 1912—Hours steaming	464	462
Cost of material and labor	$63.35	$77.74
March 1912—Hours steaming	424	182
Cost of material and labor	$1.71	$253.02*
Cost per kw.-hr. in 12 boiler installation, with two boilers for one 20,000-kw. turbine (yearly load factor 36 per cent)		0.0034 cents

* Covers general overhauling of stoker and setting.

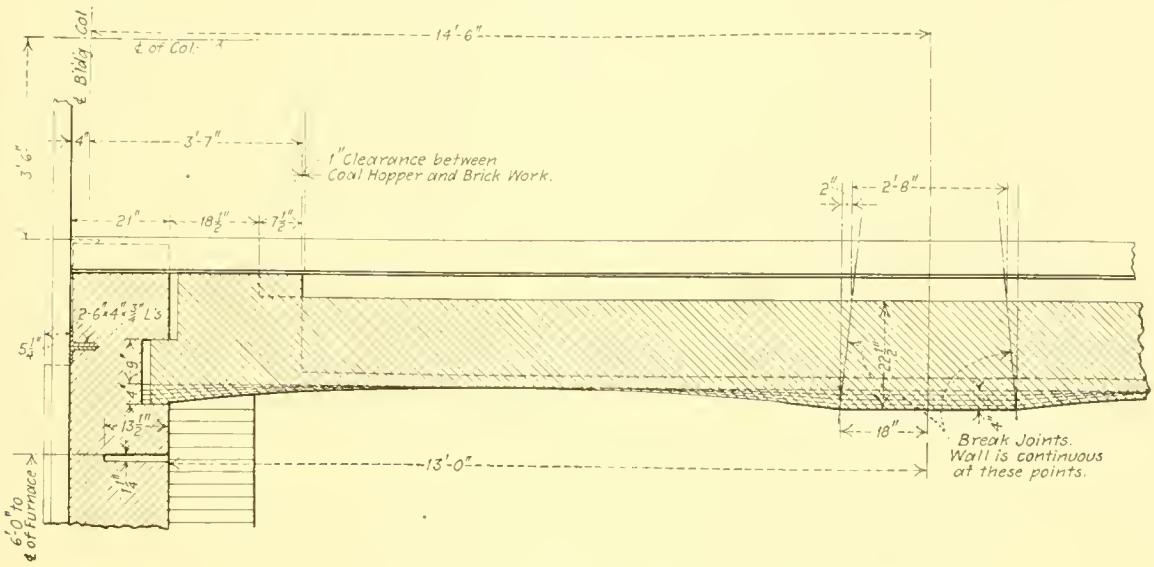


FIG. 10 DETAILS OF VERTICAL ARCH CONSTRUCTION OF FURNACE WALLS

This maintenance has, as a matter of fact, decreased since the time referred to, because of improvements worked out on the stoker dumps. The dumping plates have now been made with removable tops, so that only the part burned need be removed and the web of the casting may be left in place. By a redesign of the shape of these dumping sections only one pattern is made use of, and the labor cost of replacing burned parts has been greatly reduced at the same time. In 1912, one stoker was completely rebuilt in order to experiment with various changes of design, especially of dumps, which have required most frequent renewal.

Setting Repairs. The settings of these boilers consist, as was stated before, simply of four walls without arches or bridge walls. (See Fig. 3.) The only brick repairs necessary thus far with this setting have been the annual rebuilding of part of both front walls (area 150 to 175 sq. ft.) extending from the stoker to the mud drum of the boilers. The end walls give no trouble when carefully bonded to the facebrick of the setting. As an experiment, the front walls of one unit are to be built of fire brick shapes, supported by a cast iron or steel supporting frame. This construction will involve a sheet steel casing to make the setting air-tight, and will be less like a wall, and more like a steel casing protected from the fire by fire brick which are not self-supporting. In the last two units installed this autumn the walls are built with the surfaces slightly concaved on the fire side. The plan section is an arch, as shown by the detail drawing reproduced in Fig. 10.

Since each individual fire brick in a wall exposed to the fire on one side tends to expand permanently on the hot end, the tendency also is for each brick to pull in towards the fire. Bonding and anchor bolts ordinarily prevent this, but at some points, the influence of bonds and local anchoring is not enough to prevent large areas of the wall from falling toward the fire. The object of the "vertical arch" design referred to above is to wedge each individual brick into the wall by an arch construction and thus prevent the walls from bulging. The results, of course, remain to be seen.

Roney Stoker Settings. The most educative experience with brickwork has been had with the Roney stoker settings and their furnace arches. Starting

with two sprung arches under each mud drum with a central wall intersecting the bridge wall at right angles, the design ended up with a single continuous "flat arch," so called, under the mud drum, built of fire brick shapes hung from cast iron rail beams. (See Figs. 7, 8 and 11.) For these shapes a special brick had to be made of an exceedingly loose texture obtained by mixing sawdust with the clay before moulding. Upon burning in the kiln, this sawdust burned out, leaving the brick very porous. It was found that a harder, closer grained brick invariably spawled under the repeated heating and cooling to which it was subjected.

Limitations of Boilers as at Present Installed—Furnace Height. As at present installed, these boilers present certain limitations to being driven at any considerably higher per cent of rating than that already obtained. First, in burning West Virginia, long-flaming bituminous coal, it is probable that at, say, 275 per cent of rating and perhaps somewhat lower than that, the flames will reach the top of the combustion chamber, which is twenty-eight feet high. As soon as uncombined combustible gases get over into the superheater pass, the over-all efficiency of the unit will drop, for although secondary combustion will take place, nevertheless some unburned volatile matter must escape. Smoking will begin immediately after the secondary combustion becomes very considerable.

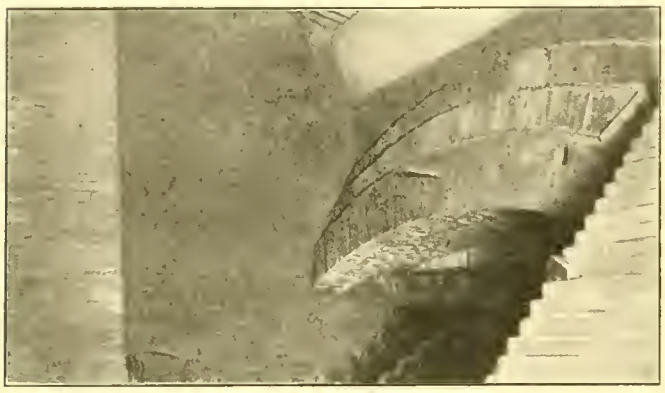


Fig. 11 Photograph of Arch for Roney Stoker

If the boiler in future installations is set much higher another difficulty will arise, although this is not so serious. Either more stack draft must be provided, or a pressure will be developed at the top of the combustion chamber, and the brick setting at this point must be built gas-tight. This phenomenon is readily explainable. Inside the combustion chamber is a column of gas like the column of gas in a stack. This stack is only 26 ft. high between draft gages in the present settings, but the gas column is at an average temperature of about 2300 deg. fahr. Figured statically this would create a draft of 0.3 in. of water at its base, providing the pressure at its top is atmospheric. However, if the maximum stack draft obtainable is reached at 250 per cent of rating with the present breeching and stack arrangement, the draft over the fire might become at 275 per cent of rating, only 0.1 in. As figured, this gas pressure over the fire must be less than at the top of the chamber by 0.3 in., neglecting friction. The pressure at the top would, therefore, become 0.2 in. above atmospheric. Pressure at this point is frequently developed in practice with the present settings.

Internal Losses of Pressure. Another limitation is the drop in pressure through the superheater, the automatic check valves and stop valve of the boiler. At 210 per cent of rating on one boiler, the drop in pressure through the superheater is 21 lb. which includes the pressure drop through the automatic check valves, but not that through the main stop valve. At 255 per cent of rating it would be considerably more. Since the pressure on the steam mains must remain constant, a pressure must be carried on the saturated steam drums of the boiler of 21 lb. more than at the superheater outlet, when running at 210 per cent of rating.

DISCUSSION

R. H. Danforth (written). The results of operation of this set of boilers, as reported by Mr. Parker, are no less startling than were the tests of the first three of these gigantic units, described by Dr. Jacobus in his unique paper.[1]

It is evident from Fig. 12, which shows a graphic comparison of the overall boiler efficiencies at different steaming rates, as obtained by Dr. Jacobus, with those shown in Fig. 4 of the present paper, that the extraordinary efficiencies obtained under test conditions have been not only maintained in service, but even improved by more than 1 per cent.

Of course this does not mean that boilers, like wine, improve with age. It can mean but one of two things in the present case, or perhaps a combination of the two; namely, a reduction in the temperature of the flue gases, or an improvement in the furnace efficiency.

Mr. Parker gives no data in his paper as to the losses in the flue gases, but if we refer to test No. 8, Table 16 of Dr. Jacobus' paper (the best test there reported, showing an overall boiler efficiency of 80.28 per cent at 108 per cent rating), we find that the flue gas temperature is 493 deg. fahr. and that of the steam at 200 lb. gauge is 388 deg. fahr., a difference of only 105 deg. fahr. This means that even if we could so improve this boiler as to discharge the gases to the stack at the same temperature as the boiler steam (assuming that the chimney draft thus provided would be sufficient to take away the gases), we could increase the overall efficiency of the unit by but slightly over 2 per cent.

Going again to Dr. Jacobus' paper, in the absence of sufficient information in Mr. Parker's, we find but 1.8 per cent of the available carbon lost in the ash, a very satisfactory showing for mechanical stoker operation, and one which we believe can hardly be bettered.

[1] Tests of Large Boilers at the Detroit Edison Company, Trans. Am. Soc. M. E., vol. 33, p. 565.

In Table 5 of Dr. Jacobus' paper, for Test No. 8 the CO in the flue gases was 0.02 per cent at the bottom of the last pass, 0.01 per cent at the top of the last pass, and 0.10 per cent in the flue. These discrepancies were discussed in connection with the presentation of the original paper, so we need not attempt to discover their cause. If, however, we assume even the highest of these values, 0.10 as the correct one, a completeness of combustion is indicated, which we can hardly hope to materially improve.

This test No. 8 of Dr. Jacobus' also shows a flue gas analysis which indicates a very moderate excess of air above that theoretically required to burn the coal, amounting to from 25 per cent to 40 per cent, depending upon the assumptions made as to the hydrogen in the coal and the steam-gas in the flue gases. It seems hardly credible that Mr. Parker has succeeded, with any form of stoker, in so improving the mixture of air and combustible gases in his furnace as to reduce this item of loss to any great extent.

I am unable to discover, from this analysis of the original tests on these boilers, any probable source of the improvement in their efficiency which he indicates, especially under operating conditions as against test conditions, even though the operating conditions are such ideal ones as Mr. Parker describes. I would like, therefore, to have Mr. Parker give us any data which are available, of flue temperatures, gas analyses, etc., which will indicate in what direction he has succeeded in making his gains, and obtained the marvelous operating efficiency which he reports. In so unusual a record of operation, Mr. Parker has set a mark quite as high, if not higher, than did Dr. Jacobus in their design.

Alex Dow said that the theory of the Detroit Edison management had been not merely to reduce floor space, to reduce the unit investment, and to secure a very high operating efficiency of the mechanism, but to demonstrate that in the boiler room, as in other departments, it was possible to pay larger daily or hourly rates to employees, and to get results that would warrant these rates.

Looking broadly at the proposition, the vital point had been the reduction of the number of firemen, and the education of those fewer firemen until they developed and demonstrated such interest in their work, as was evidenced by their insistence on checking their running instruments. A very much higher class of men could be obtained if the equipment were given them to show the interesting processes which they were carrying on. The firemen at the Detroit Edison plant were beginning to comprehend that they were carrying on exact chemical processes; that they had to watch not only the draft and the appearance of the fire, but also the CO_2 recorder. These firemen often went to the engineering department and asked for an Orsat apparatus to check up their recorders.

Ideals were not always realized and human nature had continually to be compromised with, but Mr. Dow felt that the approximation of daily practice to theoretically perfect working was much closer in the Detroit Edison Company's boiler plant, for the present year, than in any other plant in the country.

Albert A. Cary was interested to know what the experience had been, as far as checking was concerned, with the flow meters used in the Detroit Edison Company's plant. His experience had not been very satisfactory in that direction, and he wanted to know if the firemen had any other apparatus to fall back on in case the flow meters failed to give the proper records or not.

I. E. Moultrop said that in times past managers of plants took interest in their engine rooms, and let the firemen run the fire room. But in the fire room were to be found the greatest possibilities of economy in the operation of the power plant, and it should be in charge of the most intelligent men in the operating department. It was gratifying to see that the Detroit Edison Company was working along that line.

In answer to Mr. Cary, he said that he had had considerable experience with steam flow meters in Boston, and thought that they were quite accurate. As to the matter of checking, there was no instrument in the plant that was good for much if it was not periodically and systematically checked.

He had come to the conclusion that the CO_2 recorder was not so valuable an instrument as it had been assumed to

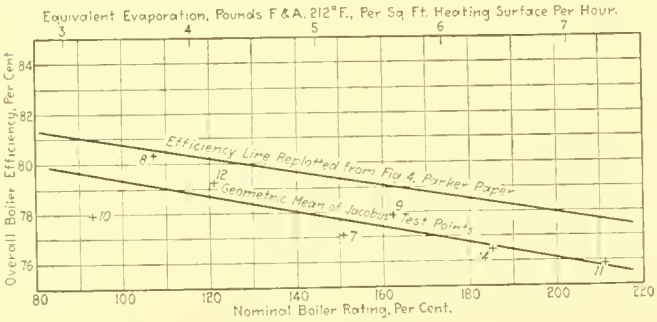


Fig. 12 Comparative Curves showing Relation between Results reported by Mr. Parker and those obtained in Dr. Jacobus' Tests on the Same Boilers

be in the past. With feedwater regulators and steam flow meters, and with the intelligent help in the fire rooms of today, the CO_2 recorder was one of the least valuable instruments on the control board. Mr. Moultrop did not mean, however, to condemn the instrument as a piece of boiler room apparatus. He believed it was a more delicate instrument than others and required more attention to keep it in satisfactory working condition. It had one disadvantage: the other instruments mentioned showed what was taking place in the operating of the boiler, whereas the CO_2 recorder told what had happened sometime previous, the lag being somewhere between 5 and 20 minutes' duration. The fireman was not especially interested in post mortems; moreover, an intelligent fireman would find ways of getting satisfactory CO_2 readings on his recorder without necessarily getting ideal conditions in his furnaces.

George B. Preston had found that one of the principal difficulties in starting up large boilers was in connection with the fire brick lining and the combustible arches, and he wished to ask what material Mr. Parker found to be the best, and if he had any illustrations showing the failure of these brick arches.

Roger DeWolf asked what connections there were, if any, between the blower supplying the air to the stoker and the drive for supplying the coal. He also wished to know if Mr. Parker would consider a semi-automatic control for the blower, at least as being a desirable proposition. A

new equipment of 875-h.p. boilers was being installed in Rochester using a semi-automatic control on the blower and a motor-driven feed for the coal, which was entirely in the hands of the firemen for operating.

Mr. DeWolf agreed with Mr. Moultrop regarding the use of CO_2 recording meters, but would like to have further details. In the above installation it was being arranged to measure the feedwater continuously in order to get continuous records of the feedwater and of the amount of coal burned, and it was expected to rely on these, together with steam flow meters on the boilers, rather than on any CO_2 determinations.

William Kent (written). The CO_2 recorder is a necessary evil; it must be used if the best economy is to be maintained. There is no record of tests that I know of (where several tests in succession gave high efficiency) published either in this country or in England, where the CO_2 meter, or the Orsat, or the Hempel apparatus for determining the CO_2 was not used. I have in mind an apparatus using oxygen instead of carbonic acid gas. The maximum efficiency is coincident with 3 to 7 per cent of oxygen in the chimney gases, and if there is 5 per cent of oxygen in the chimney gases it is as nearly right as it can be. With the CO_2 meter on the other hand, if there is 15 per cent of CO_2 the economy might be high or it might not, because 15 per cent CO_2 means the possibility of a good deal of CO in the gas.

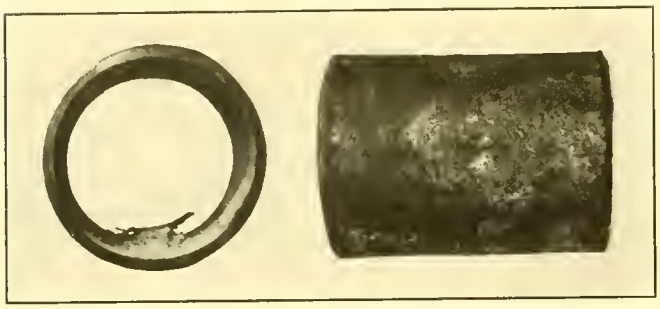


Fig. 13 Cross-Section of Tube, and Outside of Tube showing Leak

The control of the boilers, as described in the paper, so as to obtain the maximum efficiency, is effected by two things acting together: First, the disappearance of the flame at the top of the combustion chamber, which shows that the combustion of available gas is entirely complete (wherever there is a visible flame there is imperfect combustion; that is, the flame must extinguish itself by burning out so that the combustion is entirely complete to insure that the operation is smokeless). Second, the CO_2 should be about 13.5 to 14. The two things are necessarily taken together: If there is smokeless combustion there may be maximum economy, but on the other hand there may be poor economy on account of a possible great excess of air. In order to avoid the error of a great excess of air, therefore, the CO_2 apparatus must be used.

Reginald P. Bolton said that these boilers were a wonderful exhibition of what might be expected in the future construction of boilers intelligently designed to give the gases a chance to burn themselves out, giving complete combustion before the gases got out of the boiler. Another lesson to be learned from these boilers was the effect which such large power uses had in improving the morale and the conditions of the working forces.

As to the ineffectiveness of the CO_2 recorder, Mr. Bolton was inclined to think that much of the troubles arose from the difficulty of collecting the sample. He had just come from a series of observations conducted on large stacks of the Waterside station of the New York Edison Company, during which a great variety of samples covering a long period of time were gathered from the smokestacks 200 and 300 ft. in height. From a selected point in the stack it was found, after a series of experiments, that the velocities varied all over the stack, that the contents of the stack varied, and in one case, after the medium point had been established by a series of experiments, the current of gases reversed itself in the stack at that point, and there was actually a down-flow instead of an up-flow. It might be well therefore that the poor CO_2 recorder as a gage becomes mixed up from time to time. A great deal of study had yet to be made of the flow of gases in flues and smokestacks.

D. S. Jacobus said that careful gas analyses were made in his tests and had not the CO been carefully measured as well as the CO_2 it would not have been possible to attain the high efficiencies. The presence or absence of CO was most important. If in operating a furnace it was found that there were certain indications respecting the length of the flames, or the like, that gave a line on the amount of excess air and the presence or absence of CO in the gases, a furnace could be operated just as well by observing these manifestations as by making gas analyses. Indications of the sort were highly valuable in serving as a guide for securing good combustion. In Mr. Parker's tests both means were employed and contributed to the attainment of the high efficiencies.

Dr. Jacobus complimented Mr. Dow on the progress he was making in putting the right sort of men in the boiler room. He said there was more to be gained or lost in a boiler room than in any other part of a power plant, and he predicted that eventually it would be common practice to place the boiler room in the direct charge of the best men in the organization.

David Moffat Myers said that he had found a very bad state of affairs in the fire rooms of factory power plants. The management, as a rule, had not the slightest understanding of what was going on. There was usually not the best of feeling between the chief and the firemen, and this was the first thing to be readjusted by the education, not alone of the firemen, but of the management. Mr. Myers had in mind a typical small factory plant which had been drifting along for a good many years in the belief that no improvement could be made. A test showed that two boilers were being fired at only half their capacity, although on certain days they were not holding steam because, as the engineer said, the draft was too weak. They were evaporating 6 lb. of water per 1 lb. of fuel. That plant was greatly improved without spending any money on equipment, by educating the firemen to fire properly. Only one boiler was now being fired and with the damper closed one-third of the time to prevent steam from blowing off. One pound of fuel was evaporating 8.5 to 9 lb. of water instead of 6 lb. as formerly, and the fireman of the plant was delighted. He had been educated by practical example, was

getting more money for his services and was intensely interested in his work. The management had their eyes opened and were tremendously interested and satisfied with the results. They were making over 40 per cent more steam for the same consumption of fuel and without a dollar spent for new equipment.

The preventable losses that today existed in factory power plants were tremendous. These losses were chargeable fully as much to lack of education as to improper equipment, and the management was directly responsible for both of these factors.

For some reason it was a fact that owners would go to great expense for producing efficiency in other departments of their business while they allowed their power and heating plants to get along in the most haphazard way. A reform of education in this direction would enable the payment of wages to firemen properly commensurate to their responsibility and would at the same time largely increase the net profits of the owner's business.

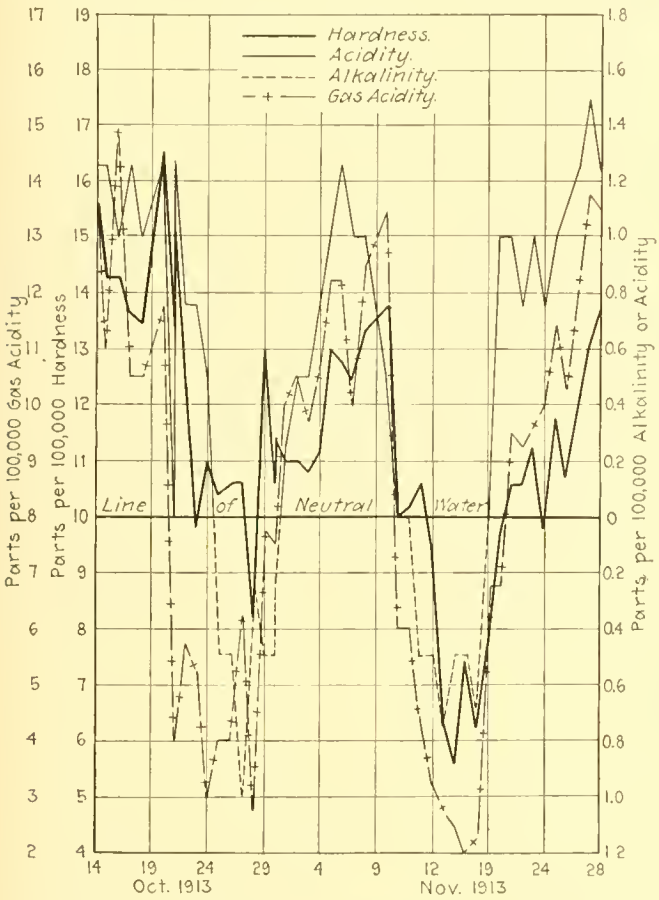


Fig. 14 Analyses of Water from Monongahela River at Rankin, Pittsburgh

Such a reform was gradually taking place, and it was bound to succeed universally for it combined at the same time the principles of science and of humanity.

Harrington Emerson, while praising the detailed information given in the paper, objected to the inclusion of violently varying maintenance or supervising costs as pertinent. There were standards for maintenance costs as well as for power costs, for supervision and for rent, and standard allowances should be used in determining final costs, not accidental variations. In the report criticized, one of the boilers cost in one month for maintenance labor and material $1.71, another cost $253.02. When such great accidental variations occur the conclusions as to cost of product which include them are vitiated.

Railroads can rightly assume a repair cost of $0.08 a mile for repairs (if this is the average), but no railroad can properly include in the cost of a single trip the destruction of a locomotive by explosion, nor yet omit the item of repairs from the cost of a particular run. In all cost accounting reference to standards is needed.

Albert A. Straub (written). Although Mr. Parker has shown by results obtained in three and a half years of operation, that the operation of so large a steam generating unit is not only feasible, but highly satisfactory, from the most important points of operation and maintenance, it seems, nevertheless, that the choice of such a unit must be governed largely by local operating conditions.

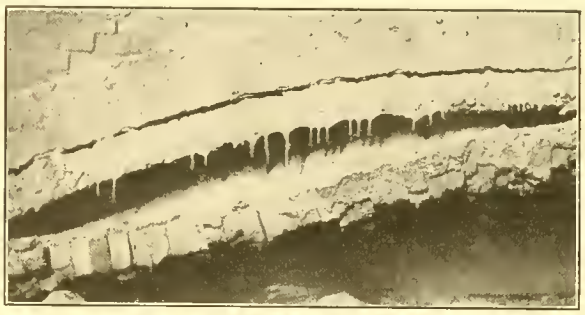


Fig. 15 View of Arch in Sagged Condition Five Days before Part of It fell

Mr. Parker stated that a scale of $^1/_{16}$ in. thickness would form in the hot front tubes, but did not state how long it took to form this scale. I judge it was formed between the periods of turbining tubes, but would desire further information on this phase of the subject. That mud will cause leaky tubes not only with $^1/_{16}$ in. or heavier scale, but with scale of egg-shell thickness, and not only at high but at moderate rates of driving is evident, as shown by Fig. 13. These photographs are of a tube taken from the lower row of tubes of a 375-h.p. Babcock and Wilcox boiler equipped with Roney stokers and having a small combustion chamber. The damaged portion of the tube was exposed directly to the action of the flame. The feedwater was taken from the Allegheny River and contained from six to ten parts per 100,000 of incrusting solids, being treated with enough barium hydrate to neutralize the sulphate content. The tube was a 4-in. No. 10 gage, lap-welded, charcoal iron tube, so placed that the weld was not exposed to the action of the flame. The photographs of this tube show that the leak occurred directly under the deposit of mud and that the scale was so thin as to have practically no effect. Observations made at other times on tubes which were renewed at this station showed mud to be the cause of overheating. The boilers at this station operate usually at rating and, for short periods, at as high as 75 per cent above rating. The question of the behavior of such a sized unit when using bad water is of vital importance to engineers of the Pittsburgh district. I have plotted (Fig. 14) 44 analyses of water from the Monongahela River taken at Rankin,

Pittsburgh, Pa., from October 14 to November 29, inclusive. Thirty-two of these analyses showed the water to be either neutral or acid as high as 1.50 parts per 100,000. Such a water as this cannot be fed to a boiler untreated and a surface condenser with such a water should not be considered.

With water of this character it has been found that cast iron will be eaten out in anywhere from two to six months, and it is a question what will happen to the tubes of a surface condenser. When using the jet condenser and treating the feedwater in a softener before it enters the boilers a large quantity of sodium salts is fed into the boiler. If the water is treated as it enters the boiler, without a softener, it has been found that a very slight concentration of sodium salts will cause the water to become wild and hard to keep in the front tubes of this type of boiler, at moderate rates of driving.

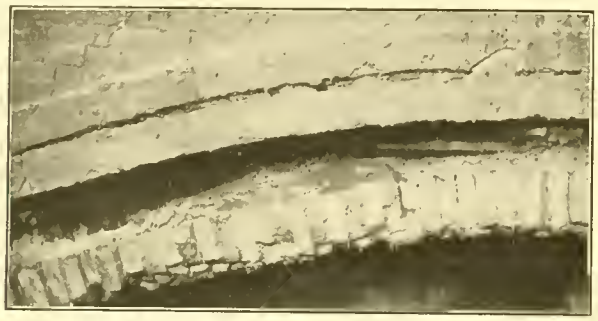


Fig. 16 View showing Arch after Part of it fell. Fallen Part patched

Mr. Parker stated that he treated the make-up water with barium hydrate, but did not state where he added it, or whether he filtered the water after it was treated. I have had the best success with this treatment if I could remove the precipitated salts in some manner before the water entered the boiler.

I note no reference to any instrument for recording temperature of escaping gases. This record and that of a recording draft gage are of vital importance, especially during periods of banked fires, where the overfeed stoker is in use.

Considerable stress seems to be placed upon having the proper CO_2 content in the gases of combustion, which no doubt is deserving of commendation. My experience has been that it is also advisable to insist upon a low combustible content in the refuse from the ashpit or there is a saving of the one at the expense of the other. Mr. Parker seems to have neglected entirely any reference to the quality of refuse from the ashpit. I should like to know if he maintains any record of this factor.

In regard to arches on Roney stokers Mr. Parker does not give any data obtained from his experience with sprung arches. Figs. 15, 16 and 17 are views of a sprung arch, which together with a history of this arch, may prove of interest.

The photographs are of an arch of one of a battery of two 375-h.p. Babcock and Wilcox boilers, Alert type of setting with Roney stokers having a grate area of 92.5 sq. ft. each. The arch is 11 ft. span, 6 ft. 4 in. long and has a spring of 16 in. The furnace temperatures observed with a Wanner pyrometer through a peep hole 1 ft. below the edge and 1 ft. from the front of the arch, when this furnace was in operation, varied from 2800 deg. to 3000 deg. fahr. This arch was made of Woodland brick and was placed in operation December 12, 1910. On April 18, 1911, the arch was in the condition shown by Fig. 15 (badly sagged), the boiler having been off for leaky tubes or general cleaning nine times in this period of four months and six days. The boiler was placed back on the line in this condition and operated until April 23, 1911, when part of the arch fell, as is shown by Fig. 16. This defect was patched and the boiler placed back on the line May 4, and operated without shutdown until June 25, when the whole arch fell, as is shown by Fig. 17. The short life of the arch was due to faulty side walls. The arches and side walls in both boilers were then rebuilt and held from August 1, 1911, to October 29, 1912; during this period the boiler was off 15 times either for leaky tubes or general cleaning.

The Author. As far as the fireman is concerned, the steam flow meter need give merely relative indications for his guidance. Extreme accuracy is not necessary for his purpose nor would a constant multiplying error mislead him seriously. The experience at the Delray plant has been, however, that, properly installed and calibrated, the flow meter is reliable and use is being made of it for *absolute* measurements of steam also.

Fig. 17 View showing Arch after it fell completely

It should be understood that the curve (Fig. 4) of overall efficiencies obtainable with the underfeed stoker, is a straight line drawn through points taken from the Jacobus tests. The actual efficiencies attained at the extreme points of the range of the tests are given in the paragraph on Flexibility in the present paper. The curve of efficiencies presented by Dr. Jacobus in his report of the tests, was intended to show the characteristics of the boiler as fired by either the underfeed or natural draft stokers. The latter tended to give slightly better results at low ratings and lower efficiencies at very high ratings, than did the underfeed stoker.

The efficiency curve of the present paper has been set up as an ideal for which to work in daily operation. The instruments on the gage board were chosen to give the fireman as much information as possible to aid him in approximating such maximum efficiencies. During a test he has other information continually at hand. Most important is the apparent evaporation, figured cumulatively from the start of the test. However, apparent evaporation is but a derived result and does not show the fireman the causes which lead to it. For judging of present conditions, it is

invaluable for him to know drafts at various points of the furnace, rate of steaming as shown by the flow meter and the record of CO_2 in the flue gases coupled with observation of the gases entering the superheater. It has been asked why use is not made in this connection of pyrometer readings of the temperature of the exit flue gases. This has been attempted, but for everyday work this exit temperature was found to be dependent upon too many other variables whose influence on it is not well enough known. During a certain test, when the rate of steaming was being held practically constant and the combustion of volatile gases was known by inspection to be very complete, the temperature of the exit gases was found to be extremely valuable in showing up an excess of air. The temperature invariably rose when the gases contained too much air and fell as the excess was decreased. It was possible in this way to predict changes on the CO_2 recorder chart, since the recorder readings lagged at least 5 minutes behind the flue gas conditions. In spite of this experience, it was decided to omit exit gas pyrometers from the list of necessary operating instruments.

The almost complete combustion which was obtained during Dr. Jacobus' tests is not too difficult to obtain every day. Flue gas analyses show almost daily as good or better furnace conditions for hours at a time. While driving these boilers at above 200 per cent of rating, and in one case at about 225 per cent of rating, the gas analyses by recorder and Orsat apparatus and inspection of the gases entering the superheater showed better combustion than that secured while running at equally high ratings during the tests. It is only natural that the firemen should become more skilled than they were three years ago. Again, with the self-cleaning stoker installed with one of the latest of the boilers, routine sampling of the ash during December of 1913 showed an average of 12.6 per cent of combustible in the ash, there being 10.2 per cent of ash in the air-dried coal.

In the discussion, further questions were asked in regard to automatic or semi-automatic control of the air supply to the stoker. Before adopting such automatic control, there is this point to be considered. The load of the plant is varying up and down 1 or 2 per cent continually, the greater variations being as a rule more gradual or else periodic. This is, of course, not considering such sudden peaks as those occasioned by thunderstorms. This sawing up and down of the load will occasion slight variations of steam pressure and this allows our taking advantage of the capacity of the boilers for heat storage in the water. It is not necessary that the rate of fuel combustion be so often changed. It would be a mistake to employ an air supply controller which would attempt to hold constant steam pressure, if in so doing it were continually to disturb the rate of combustion of the fuel.

In regard to the paragraph of the paper on maintenance costs, it was intended to show the cost of material and labor required for repairing these two units during a period immediately following the season of peak loads, when time was afforded for repairs which might have been difficult to accomplish when load conditions were more severe. Since the plant contains various types of boiler and stoker equipment, it was not desired to use for the above purpose, the average boiler, stoker and furnace maintenance costs for the whole plant, which could have been obtained from the plant operating accounts.

TASK SETTING FOR FIREMEN AND MAINTAINING HIGH EFFICIENCY IN BOILER PLANTS

By Walter N. Polakov, Philadelphia, Pa.

Member of the Society

ABSTRACT OF PAPER[1]

The determination of the practical maximum economy of boiler room operation is the subject of this discussion. The question is twofold in its nature: (*a*) how to obtain this maximum economy of operation, and (*b*) how to secure the permanency of the results attained. The first part of the question involves the theoretical research into the problem which embraces: (*a*) analysis of variables, (*b*) limiting influence of variables on maximum, and (*c*) dependence of results from time rate. This part deals with methods of experimental determination of maximum theoretical efficiency obtainable under given conditions, and incidentally refers to the graphical method of study of boiler trials as applied to actual examples of the writer's tests.

The well-known falling short of test results in everyday performances forms the connecting link with the second part of the paper, and it is shown how the results of theoretical research can be made practically obtainable in regular service. This embraces the methods employed by the writer in studying the psychophysiological element of the problem. In order that the prescribed conditions be maintained and the desired results of high economy of operation be accomplished, not spasmodically, but day in and day out, the task put before men ought to be (*a*) possible, and (*b*) desirable.

The possibility of accomplishment of task is governed by (*a*) proper coördination of conditions and supplies with power demand and existing facilities; (*b*) proper guidance of men in their work; (*c*) proper balance of strain during the work and regain of physical losses of the individual during intervals between working periods. Part (*c*) complements the common method of time studies, with a new method of physical studies of the effect of work on the health of workingmen and a method of scientific determination of length of working day.

The desirability of accomplishment of a task set within men's possibilities requires the study of: (*a*) physical stimuli, (*b*) psychical stimuli, and (*c*) social stimuli. To the group (*a*) is referred payment of bonus, better surroundings, shorter hours, sanitary conditions, etc. To the group (*b*) factors like sporting

[1] Published in complete form in the December 1913 issue of The Journal of The American Society of Mechanical Engineers. Pamphlet copies can be obtained for 15 cents to members and 30 cents to non-members.

spirit, confidence in records, relationship with management, desire to study and advance, etc., are referred. To the last group (*c*) belong such stimuli (favorable or not) as attitude of fellow workmen, of trade unions and socialist party, of members of the family, and condition of labor market, legal regulations, etc. To the above plan are added examples of records from practice, and description of methods greatly simplifying the working out of records and logs.

DISCUSSION

William Kent said he was pleased with the papers by Mr. Parker and Mr. Polakov because they went largely into the question of the human element in the boiler room. In the first paper the human element seemed to have been dispensed with as far as possible and automatic machinery substituted in its place, and secondly, in the case of those firemen that could not be dispensed with, very high wages were paid. This was an important step forward.

Mr. Kent knew of no other paper that treated so exhaustively of the human element in the boiler room as did Mr. Polakov's, and he congratulated him on his earnest efforts in that direction. In regard to the mathematical portion of the paper, he did not think Mr. Polakov had treated the subject in the right way: he had gone far into the mathematical treatment, but it did not appear that he obtained any results that were of practical value.

D. S. Jacobus believed it impossible to get up an equitable bonus system where the men in the boiler room would be paid individual bonuses. The whole organization should be taken together. If an endeavor were made to pay individual bonuses, based on the boiler efficiency secured in each case, the men would soon find out that by carrying a uniform fire they would get the best efficiency. In the case of a fluctuating load those conscientious enough to meet the variations by manipulating the fires to give more or less steam would be penalized through their inability to run at as high a rating as the men carrying uniform fires. It was hard to see how this point could be covered in any equitable system other than by considering the work of the men as a whole.

He considered that the best way of handling the situation would be to put the right sort of a man in charge in the boiler room and make him responsible for the results, in which case the men might be given an increase in pay in proportion to the amount they could save by exerting themselves to the utmost. The general idea that the firemen were opposed to improvements did not seem correct to Dr. Jacobus. He had had considerable experience in working in fire rooms to get the best out of the men and knew that if the firemen felt that the expert was in a certain sense one of them, they would do all that they could to coöperate.

Dr. Jacobus agreed with Mr. Kent that the method outlined in the appendix of determining what a boiler should do was quite incomplete. For example, there was apparently nothing to connect the baffle arrangement with the efficiency. By changing the baffle in a given boiler the heat transfer rate would be altered, say, 50 to 100 per cent, and it seemed there was nothing in the method outlined by Mr. Polakov to cover this.

H. G. Stott took exception to the curves showing the most economic loadings for various types of boilers. His experience was that the type of boiler had very little to do with that question; it was entirely a question of the furnace and the combustion of the fuel. A boiler could be driven easily up to 400 per cent rating, or even more. The arrangement of the tubes one way or another was immaterial.

In the table of the rate of boiler readings, No. 7, a fire-tube boiler with superheater, was given as the most economical one. Mr. Stott said he had efficiencies on the regular Babcock and Wilcox boiler equal to those shown in this curve; the Babcock and Wilcox boiler could be carried practically to unlimited rating. Inseparable from this question of rating was one of the economics of the plant. A plant might be run at an efficiency of 60 per cent during the peak load, and operate more economically, when the fixed charges were taken into consideration, than when running at 80 per cent. When running at 80 per cent, the boilers had to be operated at 70 per cent of the so-called rating, and above that these high efficiencies were not obtainable. At the same time, if two curves were plotted, one of the fixed charges per kilowatt-hour, and the other of the operating cost per kilowatt-hour, it would be found that for the peak load which might last two or four hours a day, the operating charges were relatively unimportant, but the greatest care must be taken to keep down the fixed charges. In other words, the number of boilers on a line must be kept down, as well as the number of banked boilers to be operated.

Mr. Stott believed the time was coming when a boiler plant would be equipped with modern combustion appliances, otherwise modern stokers, which were practically automatic and required little attention. Not firemen, but combustion engineers, or men who had graduated from technical schools, would be required then. It was impossible to get that type of man to go into the boiler room yet, but this would come about when owners of boiler plants were willing to pay more to the man who operated the boiler than to the man who operated the turbine room or the engine room, because the latter could make no change in the economy of the plant, whereas the former could make 5 to 10 per cent difference.

Albert A. Cary (written). The skill of the firemen and the ability or capacity of those who have them under their charge are most important factors in the economical operation of a boiler plant and means must be employed, during preliminary investigation work, to ascertain the part played by such men in arriving at the results obtained. Special apparatus should be used to determine carefully every individual feature included in the furnace, boiler or other part of the equipment and every variable condition which enters into the operation of the plant should be noted at the time it actually occurs. Merely taking observations during the time of a test and waiting until after its conclusion to work up all results, and then attempting to make deductions is a practice which will often lead to the overlooking of very important occurrences which would lead to a materially different method of future operation of the plant.

I have found it extremely desirable to use a system in testing by which very frequent gas analyses are obtained (not less than from six to eight per hour) and these results are chalked up on a blackboard as rapidly as they are ob-

tained. By this means it is possible to follow closely the occurrences taking place in the furnace during the course of a test. When making hand-fired tests, I use a device which tells exactly the number of seconds the furnace doors are kept open. Together, these two means serve to size up the value of a fireman very quickly and the comparative merits of two alternate firemen become very apparent in a short period of time. This subject was treated at considerable length by me in a series of papers[1] written for the Iron Age.

It is to be hoped that Mr. Polakov will make his mathematical discussion of this subject a little clearer in revising this paper. The value obtained by using such a method as described by him is, however, governed by the correctness of the observations obtained during test, and as these test results are so commonly in error, the general use of such an analysis may prove unsatisfactory. It may prove desirable to use this graphical method in some one plant where the repeated errors may be fairly constant, and under such assumed conditions, introduced improvements will doubtlessly be made apparent.

I have had considerable experience with Segar cones for determining furnace temperatures and have found that the true furnace temperature could not be obtained through their use on a poker, as was shown by Mr. Polakov. I have found their general use so unsatisfactory that I have abandoned them entirely. The proper use of a good optical pyrometer will give the most reliable results.

Referring to the statement as to the unpracticability of getting a gas analysis every three minutes, I have not only obtained the ordinary gas analysis (including CO_2; O; CO and N) for 3 minute intervals, but have also succeeded in obtaining the complete analysis of the gas including H and CH_4 over 3 minute intervals. But generally, in refined boiler testing, intervals between analyses should not be over 10 minutes.

Mr. Polakov states that the weight of the steam generated is in direct proportion to the weight of fuel burned. I hardly think that he intends this statement to cover operation below rating, at rating and when the boiler is being greatly forced. Also he speaks of having the firemen carry the fire bed at a uniform thickness; this is hardly practical in hand-fired practice where, after cleaning, a comparatively thin bed is started which is increased in thickness up to the time of the next cleaning, although the use of good shaking grate bars will remedy this condition somewhat.

Mr. Polakov showed a large number of factors used to arrive at the useful result obtained in steam generation, but these only serve to complicate and obscure a rational consideration of the problem. I make it a practice to determine the individual efficiency of the furnace, and study my furnace conditions apart from the balance of the combination. I then determine the individual efficiency of the boiler and study it by itself, and find whether the boiler is operating under improper furnace or other conditions.

Unfortunately, boiler efficiency is not a fixed quantity under varying conditions of operation, depending largely, as it does, upon the operation of the furnace; with no fire in the furnace, the boiler has no efficiency at all. But, during the course of any particular test, the boiler has its individual efficiency for the set of conditions found at that time, and the study of its efficiency in connection with its controlling conditions shows us where we can improve the defects under which it is operating. These, if remedied, will raise the efficiency of the entire steam generating unit.

The efficiency of the boiler has long been considered and obscured in the reports of *combined* boiler and furnace efficiency, as this combined efficiency is composed of the product of the furnace and boiler efficiencies. When a low combined efficiency results during a test, how are we to know whether the fault is in the boiler or in the furnace? Inference may help us somewhat, aided by the observations taken, but this old time "cut and try" method of making improvements is not in keeping with modern engineering efficiency practice.

R. J. S. Pigott, referring to the diagram showing most economic loadings for various types of boilers, thought there was still a good deal of misapprehension among most engineers as to the economic point of loading both of a boiler and of a turbine. He found that the efficiency of the boiler and of the turbine had much the same characteristic, namely, there was a dome or high point at some place in the load: with the turbine it was usually at full load that the best efficiency occurred; beyond that point there might be some 25 or 50 per cent capacity allowed for overload. In the boiler this best loading occurred very low in the total capacity of the boiler, about one-third or one-quarter of the maximum capacity. The total rating of the engine room consisted not only of the usual rating of the turbine, but also of the auxiliaries necessary to run the turbine; in other words, the water rate of the turbine might be 12 or 13 lb. per kw. at its best load, but when the load required to drive the auxiliaries was superimposed, the water rate was much higher, possibly 16 to 18 lb., and the best water rate, including the auxiliaries, was always at a higher load than the best load on the turbine only. This was also true of the boiler room, the auxiliaries required in this case, the forced draft fans and possibly induced draft fans, the boiler feed pumps, etc.

While the condenser auxiliaries ran with a practically constant amount of steam, no matter what the load on the turbine, the units in the boiler room were different and required somewhat less steam at lighter loads than at full load. For instance, with a centrifugal boiler feed pump the total steam consumption at zero delivery was seldom less than 55 per cent of the steam at full load on the pump.

If the net output of steam per boiler delivered by the boiler room were considered, the most efficient point would always be at a higher load on the boiler than the best efficiency of the boiler alone.

Edw. A. Uehling (written). Mr. Polakov's paper brings out two very important points: First, it emphasizes the fact that the boiler house is the place where the greatest savings can be made, and second, that boiler efficiency tests are of very little economic value unless adequate means for guidance and control are inaugurated, and due consideration is given to the human element.

The economic conditions found in the plant under consideration in Mr. Polakov's paper are those prevailing in the majority of steam boiler plants. The fact that a "saving of approximately 25 per cent on the fuel bill alone was

[1] Iron Age, Vol. 90, p. 832; 900; 1012; 1026

accomplished without heavy capital investment" for equipment and alteration of plant, etc., except for the necessary apparatus and instruments for control and guidance of the boiler room crew, should serve to arouse all those power plant managers who have given the question of fuel economy insufficient thought, or have attacked the problem only in a more or less superficial way. It is still insufficiently realized that maximum fuel economy cannot be maintained where the personnel of the boiler room are compelled to work without means to guide them in the performance of their task and without incentive to improve their efficiency.

As to the necessity of keeping the fireman informed how well he is, or has been, performing his task, there can be no question; as to the best method of accomplishing this end, opinions may differ. Mr. Polakov presents a very complete bonus system which is no doubt effective, and the principal cause of maintaining the high efficiency reported, but it is too elaborate to merit wide application. I would also question the rationale of his guide to efficient firing controlled entirely by the steam flow meter indicating the thickness of fire and draft to be maintained; there is no constant relation between draft and thickness of fire. The effectiveness of a given draft is modified by several factors: (*a*) the conditions of the fire as affected by the size of the coal, which may vary greatly from hour to hour, (*b*) the thickness of the ash bed, and (*c*) the presence of clinkers. Thus 0.6 in. of draft may be less effective when the fire is dirty than 0.4 in. after it has been cleaned. Mr. Polakov does not say whether all the boilers are controlled by one flow meter on the main steam line, or whether every boiler is equipped with an individual flow meter. In the former case, how can a fireman tell whether *his* boiler is making its full share of the steam required? In the latter case, the less an individual boiler does, the less the indicator will show what it ought to do. It would seem, therefore, that a guide to the fireman controlled by a steam flow meter would be of questionable value. The success which Mr. Polakov scored in attaining and maintaining the high efficiency is due:

a To putting the plant in the best possible condition and selecting the most profitable kind of coal;

b To thoroughly instructing the personnel of the boiler house and providing for their legitimate comforts;

c To the inauguration of a liberal bonus system, based on the actual efficiency of every individual fireman, and

d To the most admirable system of investigating every shortcoming as to its reason, in order to determine whether it was due to the man, or to something over which he had no control, and if the latter, to at once remedy the cause.

The fact that in order to carry out the above plan, it is necessary to correctly meter the water to every individual boiler, to keep tabs on the water wasted in blowing off and that fed to boilers banked, and to weigh out the coal for every individual fireman for each shift; also to make the necessary calculations and write out the individual reports, etc., necessarily brings up the question whether equally good results may not be obtained by simpler means.

Mr. Polakov mentioned several other ways in which it has been attempted to inaugurate bonus systems for firemen, all of which he doomed to failure. Among others he mentions the attempt to base such a bonus system on the percentage of CO_2 contained in the flue gas. Of this, he says, "The high percentage of CO_2 in the flue gas was adopted as a task basis for firemen in several plants, but the men were not trained nor were they shown how to obtain it. When they occasionally attained the mark, the question remained undecided whether the high percentage of carbon dioxide was coincident with the most economical steam generation or not, and the method proved generally unsatisfactory."

I ask the question: How could it be otherwise? Would not Mr. Polakov's system prove worthless if carried out in the same slovenly way? It can be safely stated that wherever CO_2 has failed to be a true guide to efficient firing, it has been due to similar causes.

It is an indisputable fact that of any given boiler fired with the same fuel under the same conditions, the higher the percentage of CO_2 within the limits of practically complete combustion, the higher will be the efficiency. Any exceptions that may have been noted are always due to variations in the fuel, either physical or chemical or both, type of boiler, type of furnace, rate of driving, etc., etc.

For example, excessive stack temperature due to hard driving, or insufficient heating surface, or a dirty boiler, may easily neutralize the benefit due to several per cent of CO_2, and thus it may, and does frequently happen, that the same boiler driven more moderately, resulting in a low stack temperature, may show a higher efficiency with a lower percentage of CO_2 in the products of combustion. When the results from boilers of different types operating under quite different conditions are compared, the apparent contradiction to the above statement may appear even more obvious. None the less the fact remains, that in every case where a comparatively low efficiency is obtained with the high percentage of CO_2 it would have been still lower if the CO_2 had been lower, and where a comparatively high efficiency results from a lower percentage of CO_2 it would be correspondingly higher if the CO_2 had been higher, and these apparent contradictions do not all militate against the value of CO_2 as a guide for, as well as a control, over the fireman. Wherever exceptionally high boiler efficiency has been achieved and maintained, a high percentage of CO_2 in the flue gas has been obtained and maintained.

The high standard set by Dr. Jacobus by the efficiency tests of the large boilers at the Delray Plant of the Detroit Edison Company was achieved with a percentage of CO_2 averaging over 14 per cent, and this high standard of efficiency has been practically maintained under every day working conditions, using the continuous recording and indicating CO_2 meter as the principal guide for the firemen, as reported in Mr. Parker's paper.

That this cannot be otherwise becomes self-evident, when we take into consideration the fact that up to 90 per cent and more of the heat loss in the generation of steam in the average boiler, passes up the chimney, and that the heat loss is the product of weight of the products of combustion, the temperature at which they escape multiplied by the specific heat, and that the weight increases rapidly as the CO_2 decreases and that the temperature is not materially changed, due to the percentage of CO_2 in the flue gas. The above statements are fully verified by the figures given by Mr. Polakov in Appendix No. 3.

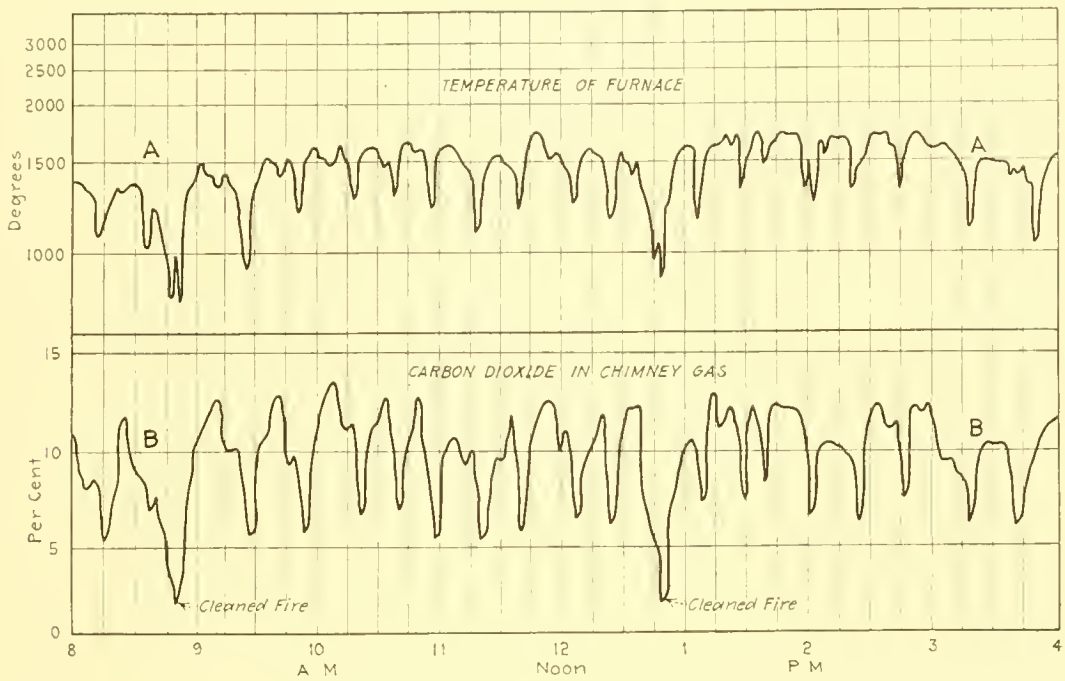
Much stress is laid on the danger of losing more by the presence of CO in fuel value due to high CO_2, than is gained

in reducing the loss of sensible heat by reducing the weight of the flue gas. While I, by no means, wish to under-rate the importance of complete combustion, I do believe that there is much misconception regarding this point. In a paper,[1] Combustion and Boiler Efficiency, read before the Society three years ago, I believe to have demonstrated by some 1100 odd flue gas analyses that there is no relation between the content of CO and CO_2 in flue gas; that low CO_2 is no guarantee that combustion is complete and high CO_2 is not necessarily accompanied by an appreciable percentage of CO. This fact is also borne out by the flue gas analyses reported by Mr. Polakov, which showed that the lowest percentage of CO_2 was accompanied by the highest percentage of combustible gases. Complete combustion depends much less on a large percentage of free oxygen than on the method of firing and the construction of the furnace, and most of all on the furnace temperature, and inasmuch as an unnecessary amount of excess air lowers the furnace temperature, very low CO_2 is more likely to be accompanied by combustible gases than rationally high CO_2

It has been abundantly demonstrated that with correct furnace construction, thorough instruction and proper treatment of the firemen, and by providing them with adequate means for their guidance and control, 12 to 15 per cent of CO_2 can be regularly attained without appreciable amounts of CO and maximum efficiency thereby maintained. It has also been demonstrated that a large excess of air, i. e., a low percentage of CO_2, is no guarantee against incomplete combustion, that sporadic boiler tests and occasional gas analyses are of little value, that half-hearted attempts with an inadequate means for guidance and control cannot succeed and are therefore a waste of time and money.

To insure success the conditions must be studied, radical defects must be remedied, the firemen must be instructed and their legitimate comforts considered, an incentive to excel must be given, and above all, adequate means for their guidance and control must be provided. The correctness of the above general proposition will be conceded by all who have given the question of boiler house economy due consideration.

Dr. Kent made the statement, "If we could get a continuous record of the furnace temperature, we should have no need of CO_2 recorders." This statement is apparently corroborated by the fac-simile of two records shown herewith, which were made simultaneously by a combined Uehling CO_2 meter and pyrometer. The gas analyzed was drawn continuously from a Babcock & Wilcox boiler near the uptake, and the temperature was taken a few feet back of the bridge wall. These two records corroborate one another to a remarkable degree, and that one could apparently serve as well as the other as a guide and control of combustion efficiency. It will be noted, however, that CO_2 gives the more pronounced record. The temperature is also less valuable than the CO_2 because it is not a direct factor in determining the loss up the chimney; it is also unreliable, in that it is impossible to distinguish whether the variations in temperature shown by such a record are due to irregular driving or irregular air supply. But such determinations are impracticable because there is no pyrometer available that can stand up continuously under the high temperature of a boiler furnace.



Simultaneous Records of Furnace Temperature and CO_2 made by Combined CO_2 Meter and Pyrometer

Dr. Kent has also frequently called attention to the fact, borne out by all efficiency tests, that the best results are obtained when the percentage of oxygen in the products of combustion ranges between 5 and 7 per cent, and he has strongly advocated the substitution of oxygen for CO_2 in the control of combustion efficiency.

I have shown also in my paper "Combustion and Boiler

[1] Trans. Am. Soc. M. E., vol. 32, p. 1215.

Efficiency" by coordinating the flue gas analyses of over 1100 boiler tests, that the percentage of oxygen increases as the percentage of CO_2 decreases, and vice versa. This relation necessarily follows from Alvogadro's law. When burning bituminous coal 7 to 5 per cent of O corresponds to about 11.5 to 14 per cent of CO_2, which is good practice. Theoretically, therefore, it would be quite immaterial which of these two constituents was adopted as the basis of control. Practically, however, CO_2 has everything in its favor; first, because it is very easily determined, whereas O is determined with greater difficulty, and second, because of this fact there is no oxygen recorder on the market, whereas there are several very good CO_2 recorders available.

There are two fundamental principles on which a bonus system can be established. It can be based (*A*) on the ratio of the heat output in the form of steam to the heat input in the form of fuel, or (*B*) on the ratio of the heat input to heat wasted up the chimney.

(*A*) If based on the boiler output we must know (*a*) the weight of coal fired under every individual boiler and (*b*) its average heat value for each shift and fireman. Second, we must know (*c*) the weight of water fed into every boiler, (*d*) its average temperature, (*e*) quantity wasted in blow offs, etc., for every boiler and shift, and also (*f*) the amount of superheat or priming. From these six factors the exact standing of every fireman in terms of efficiency can be calculated and the correct bonus determined.

To determine these data means must be provided (*a*) to weigh out the coal to every boiler for every shift, (*b*) to analyze every car of coal received, (*c*) to meter the water into every boiler, (*d*) to record its temperature, (*e*) to record the temperature and pressure of the steam, and last, the data must be promptly collected, correctly coördinated, and accurately calculated, for which important work a competent clerk must be available for every shift. To be an active stimulus for proficiency every fireman must be informed whether he earned a bonus, not later than the beginning of his next shift.

At the expense of accuracy this method may be materially simplified by assuming (*b*) that the coal is of uniform quality, (*d*) that the temperature of the feed water does not vary, (*e*) that the quantity of water blown off, etc., is the same for each boiler and shift, and (*f*) that the quality of steam is constant.

(*B*) If a bonus system is to be based on the heat wasted up the chimney, we must know (*a*) the average percentage of CO_2 in the products of combustion as they leave the boiler, (*b*) their average temperature, and (*c*) the rate of driving. These three factors give all the information necessary. (*a*) Determines the efficiency of combustion, (*b*) shows the efficiency of absorption, and (*c*) tells whether the fireman is doing his full share of the work. These three factors must be autographically and continuously recorded for the purpose of comparing and scrutinizing as well as for the purpose of estimating the bonus. Instruments are now available which will record these three factors on one chart. This reduces the number of charts from three to one, which reduces the time to scrutinize the records, and to average up and estimate their value to one-sixth or less of that required if the data must be taken from three separate charts.

To get the best results it is necessary that the fireman should know what he is accomplishing *all the time*. He must, therefore, have indicators at or near the boiler front which will continuously show the rate at which he is driving his boiler, the percentage of CO_2 he is producing and the stack temperature. With this information before him, he can see all the time whether he is operating on a bonus earning scale or not, and this knowledge will not only stimulate, but greatly aid him to get the best results. The pilot steam gauge used at the Delray Plant is an excellent idea, where the load varies greatly, as thus keeping the firemen continuously informed, obviates the necessity of making a written report to each fireman every day. Estimating the bonus once a week is quite sufficient. This reduces the clerical work required to a minimum.

Determining the bonus according to method (*A*) if fully carried out has in its favor great exactness, also that it shows the daily cost of steam production, and it also gives the necessary data, by which the coal can be purchased on the heat unit basis, the economic importance of which is not sufficiently realized by coal consumers.

On the other hand method (*B*) has in its favor greater simplicity, more general adaptability, and above all the immediate and continuous occular exposition of the complete process of heat production and absorption, and the continuous autographic record of the three controlling factors, in the best possible form.

The cost of the apparatus and appliances necessary will probably not differ greatly. The cost of up-keep and attendance, including the coal weighers and chemists, will no doubt be largely in favor of method (*B*). Either method if consistently carried out will give maximum efficiency.

The procedure necessary to establish the maximum normal efficiency obtainable in any given plant may vary greatly in detail, but the broad principle outlined by Mr. Polakov must be followed. Whether it is necessary to employ an expert depends on the availability of adequate home talent. Generally it pays to get expert advice. Unless the plant embodies fundamental defects, costly changes are generally not necessary to produce good results. In the majority of cases, it is only necessary to put the plant in proper working order, educate the firemen, or give them the means and the incentive to educate themselves, by inaugurating a bonus system.

Mr. Polakov raised the efficiency of the Warrior Ridge power plant from 54.2 per cent to 78.78 per cent by increasing the percentage of CO_2 in the flue gas from an average of 4.3 per cent to 12 per cent. The high efficiency established in this plant can be maintained only as the high percentage of CO_2 is maintained; there, as in every other case where high efficiency is attained, CO_2 is the most conspicuous single factor.

In conclusion a few words to those who claim that CO_2 recorders are unreliable, and they are continually getting out of order. They are neither infallible nor fool proof. In this they do not differ from any other apparatus or machine, a common pump for example. A steam pump is not a very complicated apparatus and is considered most reliable, but it will not draw water if the strainer is choked up, or a chip gets under the discharge valve. If such a pump be placed in some corner of a plant in charge of *nobody in particular*, it is a moral certainty that this pump would be inoperative the greater part of the time. Nine times out of ten that is the situation where CO_2 recorders of modern type (obsolete

apparatus are not considered here) fail to perform their legitimate function. In the majority of cases it is even worse because the pump would more than likely stand on neutral ground, whereas the CO_2 recorder is generally projected into a hostile camp. It is looked at askance from the beginning and considered a despicable telltale, at best as one of those new fangled ideas that won't work anyhow.

In not one case in ten where CO_2 recorders fail to perform their proper function does the cause lie in the instrument; nine times out of ten the fault lies with the man higher up, in that he does not hold some one person responsible for its proper and continuous operation. The failure to detail some one and hold him responsible is due either to lax management or to lack of confidence in his own judgment when he decided to install such an instrument.

If the troubles complained of were inherent in the apparatus, it would logically follow that the difficulties must multiply with the number of recorders installed, whereas practically all the failures rumored about, and nearly all the complaints received are from plants where only one recorder has been installed. It is apropos to say here that the benefit derived from the installation of CO_2 recorders is in inverse ratio of the completeness of the installation at best. A complete equipment always results in marked savings, whereas a single instrument rarely shows tangible results.

C. A. Austrom (written). In preparing his paper, Mr. Polakov has wisely emphasized the human element as an important factor in the economy of boiler operation. Previous speakers have all agreed with him on this point, but it occurs to me that most of these gentlemen had in mind mainly the larger steam installations, judging from several remarks, as for instance, Mr. Stott's regarding the fact that firing should be in the hands of educated and trained engineers, instead of as in the past by ordinary firemen. In large plants where the firing is done mechanically, this can be accomplished without much difficulty, but in the multitude of small steam plants I believe that we shall in the future, as well as in the past, see the shovels wielded by the old type firemen and not by college graduates.

Very little has been done to educate firemen in their line of work, considering the great importance of such an education from the viewpoint of both individual and national economy. The economical end of boiler operation is very little understood by the average fireman and some kind of treatise, dealing with the problems involved in the economical operation of boilers, written for the benefit of these men, has been a long felt need. Such a publication has recently been issued by the Travelers Indemnity Company of Hartford, and this, I believe, is the first attempt made along these lines. It deals with practically all the factors relating to boiler economy and should be of great help to firemen and owners of small steam plants.

Harrington Emerson (written). Efficiency in boiler plants is measured by the standards set. As elsewhere, everything depends on the value of the standards. The rational standard cannot be the ultimate attained in a test run where all conditions were momentarily perfect, as on a race course. Nevertheless the test run of today becomes the expected regular achievement of tomorrow if we are able to eliminate the unstandardized conditions and operations.

Mr. Polakov's paper is exceedingly valuable because it shows ways of standardizing conditions and operations in the boiler plant. The whole paper is so good that I feel less compunction in calling attention to an omission.

Most manufacturing operations consist of the wise combination of materials, work and equipment. In boiler plants manufacturing steam the materials are chiefly the fuel, the equipment is the whole boiler plant, and the attendants are the workers. The performance of the plant depends on the initial quality of the fuel as well as on the way it is used; it depends on the initial excellence of the equipment as well as on the way it is used; it depends on the *initial quality of the attendants* as well as on the way they are used. Before expecting continuous runs of high excellence we would provide for tests of the fuel so as always to have the standard amount of B. t. u. per lb. We would similarly continuously inspect and test furnace settings, boiler joints, clean off scale or deposit inside and out, etc., etc.

How can we expect best results unless the boiler room attendants have initial aptitude and are continuously maintained in effective condition? Mr. Polakov lays stress on fuel of the necessary condition, selection and use of fuel, selection and use of equipment, use of attendants, but omits reference to the selection of men. No one would think of raising a big crop, however excellent the climate, soil and tillage, from inferior seed. Mr. Polakov has emphasized the careful adjustment of work to men, but not the equally important adjustment of men to the work.

Frank B. Gilbreth (written). Four years ago I called the attention of this Society to the necessity of a government bureau for the collective cataloguing and disseminating of knowledge regarding management, that the best methods of each individual of each generation might be recorded for all. Mr. Polakov's paper not only shows a typical advance that is being made in management, but also in the conservation of our natural resources. It shows how workers can be taught to be more efficient, to waste less coal and at the same time how to earn higher wages, and how they can perform their duties without wasting their energy.

What Mr. Polakov says regarding chairs in the boiler room brings up the subject of chairs in general in the industries. Absence of chairs in the past in the workshops has been due to general ignorance on the part of managers, but there is now no longer any such excuse. Every act, every moment of unnecessary standing causes fatigue, and fatigue must be allowed for in the determination of a fair task for each worker.

In our work of installing management I have been greatly impressed with the evidenced unnecessary wasteful hardships due to the absence of recognized rest periods in all industries. Rest periods must be had, and therefore should be recognized, although the manager of one large machine shop said: "Sitting down even when there is nothing for the worker to do doesn't look well, and also makes him lazy."

Many occupations have periods of unavoidable delay, and thus require no specially assigned rest periods; while others have no such unavoidable rest periods, and therefore should have such properly timed and scheduled in order to get the best results, least fatigue, and greatest output.

With the idea of calling national attention to the need of devices for eliminating unnecessary fatigue, we have started at Providence a Museum of Devices for the Elimina-

tion of Unnecessary Fatigue in the Industries, and although we have caused to be sent out to date 55,000 notices, the only replies that we have received have been that they "were highly in sympathy with the idea," but as they "had never given the matter any thought before" they would "be unable to send any such devices for exhibition."

Mr. Polakov's paper is a distinct addition to the literature of the science of management. There is no end to the subject. There is still great work in this line to be done, too great to be done by any but a government bureau, and I again desire to call attention to the desirability of this Society using its influence to forward the movement for establishing a national bureau for the investigation, recording, cataloguing and dissemination of knowledge regarding the elimination of unnecessary waste in the industries, and thereby bettering the condition of the workmen.

Roger DeWolf[1] asked what the connection was, if any, between the blower supplying the air to the stoker and the drive for supplying the coal. He also wished to know if Mr. Parker would consider a semi-automatic control for the blower, at least as being a desirable proposition. A new equipment of 875-h.p. boilers was being installed in Rochester using a semi-automatic control on the blower and a motor-driven feed for the coal, which was entirely in the hands of the firemen for operating.

Mr. DeWolf agreed with Mr. Moultrop regarding the use of CO_2 recording meters, but would like to have further details. In this installation it was being arranged to measure the feedwater continuously in order to get continuous records of the feedwater and of the amount of coal burned, and it was expected to rely on these, together with steam flow meters on the boilers, rather than on any CO_2 determinations.

The Author. In view of the fact that many of the points brought out in the discussion are general in character, I feel justified in emphasizing the main points.

First, the method of management as illustrated in our particular example is based on induction otherwise known as the method of scientific investigation. It is a basis of all modern positive science and is as old as Novum Organum of Francis Bacon. Applied to the art of management by Dr. Taylor it is known as "scientific management." The more exact is our knowledge of engineering sciences, psychology, physiology and political economy, the higher is our standard and the higher is the task. The accomplishment of the task is primarily based on the *system of education* of men engaged in the work. For this purpose *each particular case shall be studied individually* and all details—task, methods, implements, bonus, etc., must necessarily be concurrent with the existing conditions and circumstances.

Second, the task and bonus method is a most essential part of the power plant management, being an educational campaign with a reward to those who learn. This makes it unnecessary to hire a college graduate to shovel the coal in the furnace when he can train the others to do it well. Professor Jacobus is in sympathy with those "poor fellows who did not know the method employed by other men" and thereby missed their bonus; he sees the danger where actually lays the strong incentive for coöperation and improvements. This systematic education of the employees in order to improve their work and remuneration stands in the same relation to the selection of help as the method of using the equipment stands to its purchase.

Yet in the particular case related in my paper the question of selection is infinitely less pressing than that of supply. The location of the plant I have reference to is such that to secure any employee or summon a man to help in case of emergency often amounts to an impossibility, and the problem is not whom to hire but where to find anyone. Under such conditions we must say with all due credit to the importance and desirability of proper selection of employees, that the method of training green, and sometimes unfit, men and turning them rapidly into valuable producers is far more important. The race track is the testing department; no one would think of running a race with a dray horse, but the profit of a trucking business depends upon the skill of the drivers and planning of deliveries, and not on pedigree alone.

Third, in the past too much stress was laid on the physical perfection of equipment and this one-sided engineering is so well rooted in the minds of average managers that nearly all industrial ills and losses were believed curable by "patent" devices. Used by untrained and often underpaid and indifferent "hands," they fail to pay for their first cost. It matters not whether after rebuilding the furnaces, baffles, etc., and changing fuel the various boilers will give the characteristic curves of the same value. The most suitable coal might not be obtainable at the desired cost and the reconstruction might be impracticable under the conditions of service. The question is whether with obtainable fuel and existing equipment we know how to get all we can for the dollar's worth; and if not, to learn how the desired result could be obtained. Unless we teach and stimulate the employee to strive at the high task, the best equipment, if purchased, will again run in a haphazard manner.

And lastly, to utilize the knowledge to the fullest advantage and to control the process at will, the conditions, not results, must be watched and regulated. The instruments will show the changes of conditions, and instruction cards must tell what to do; then if the cause is properly treated, the result is gratifying whether it appears on the CO_2 chart, on auditor's balance sheet, or is reckoned in thermodynamic terms.

[1] Mechanical Engineer, Rochester Railway & Light Company, Rochester, N. Y.

RAILROAD SESSION

PAPERS CONTRIBUTED AT THE ANNUAL MEETING BY THE SUB-COMMITTEE ON RAILROADS

STEEL UNDERFRAME BOX CARS

By George W. Rink, Jersey City, N. J.
Member of the Society

In approaching a subject of such importance to railroads as steel underframe box cars, it is surprising, in view of the interchange of such cars among the railroads, that more has not been accomplished during the past five years toward standardization in design of the various component parts, particularly those which affect the cost of maintenance and require constant repairs due to wear and unavoidable accidents.

During the year 1912, there were built 107,887 box cars of various capacities and dimensions, all varying vastly in detail design of important parts which require frequent renewal, thus making it necessary for all railway storehouses to carry an unnecessarily large stock of repair parts running into very large sums of money. Standards have been adopted by the Master Car Builders' Association which have in a large measure reduced the amount of stock necessary to be carried. I believe the time has arrived to introduce additional standards affecting the maintenance of box cars which can also be applied to all types of freight cars used in interstate business.

It is reasonable to assume that every railroad manager desires to purchase cars built in a substantial manner. In the absence of standard construction and because of competition, the car builders, when asked to furnish estimates and designs, will sometimes figure on material too light for the service. This, however, is not the fault of the car builder, since, from my own experience, I know that they will gladly add the material where needed, provided they are paid a fair price for the car.

From my observation of steel underframe box cars, I must conclude that engineers did not understand the importance of low fiber stresses in the early designs of steel underframes; sufficient attention was not given to the tremendous impact blow which the center sills and car framing found it necessary to resist, with the result that large sums of money are now being spent by railroads in making repairs to these cars by reinforcing broken center and draft sills, applying larger capacity draw gears and attachments, and heavier sills. It is not alone the larger locomotives we are using today which has called for a more thorough investigation of the subject of car design and construction, but also the severe shocks which cars are receiving in classification yards. Also the superstructure of box cars should receive just as much attention as the underframe, for how can the roofs be kept in alignment on cars having wood side posts and braces and loose tie rods. The roof is bound to work loose, resulting in leaks which prevent the use of the car for certain commodities.

The application of steel underframes to old cars will no doubt prolong their lives. This is now being done by almost every railroad on cars built just prior to the advent of all-steel underframe box cars, but care should be taken, to see that sufficient metal is provided to withstand the present service requirements, keeping in view a margin of safety for the future, as no doubt it would be desirable to maintain in service for at least ten years cars to which these steel center sills were applied. The reinforcement of the ends of box cars has received attention by the Car Construction Committee of the Master Car Builders' Association, and they have presented recommendations in the way of designs for old and new box cars. This committee likewise made recommendations with a view to establishing minimum area of center sills to resist end strain.

Railway officials in charge of car repairs have seen the results of poor designing and light construction of the earlier steel underframe cars, and during the past three years have materially assisted in the development of the art by insisting upon the production of a stronger car, one that will hold together in all kinds of service with the minimum cost of repairs.

I have compiled certain relative data from designs of eight wooden upperframe cars and one steel frame car, all of which have inside lining and outside sheathing, also six steel upperframe cars with only inside lining. All of these cars represent the latest designs of box cars now being built or recently placed in service by various railroads. The data obtained have been divided into the following groups, special cars for automobiles and furniture having been disregarded:

Table 1 General dimensions of box cars with outside sheathing

Table 2 General dimensions of box cars with inside sheathing

Table 3 Dimensions of wood side framing

Table 4 Dimensions of steel side framing

Table 5 Dimensions of end framing for cars with wood side frames

Table 6 Dimensions of end framing for cars with steel side frames

Table 7 Dimensions of side door openings, size of door and distance from rail to top of floor

Presented at the Annual Meeting, December 1913, of The American Society of Mechanical Engineers.

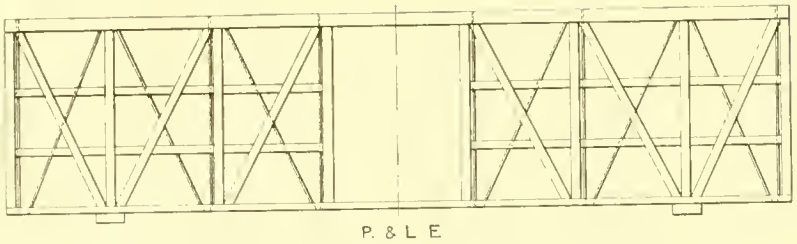


Fig. 1 Side Frame used on P. & L. E. Car Showing Wood Posts and Braces with Diagonal Rod Bracing

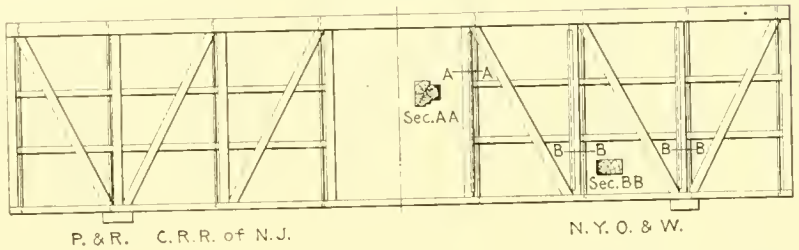


Fig. 2 Fig. 2a

Fig. 2 Side Frame used on P. & R. and C. R. R. of N. J. Cars with Wood Posts and Braces

Fig. 2a Side Frame used on N. Y. O. & W. Cars with Wood Posts and Braces; Posts Reinforced by Channels

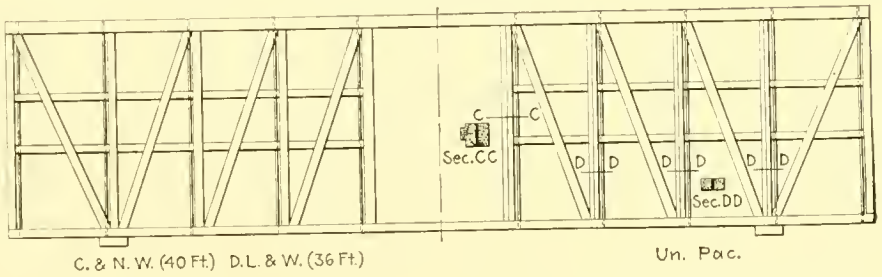


Fig. 3 Fig. 3a

Fig. 3 Side Frame used on C. & N. W. and D. L. & W. Cars having Nine Panels with Wood Posts and Braces. Type of Frame Adopted by the M. C. B. Association for Cars of 80,000 and 100,000 lb. Capacity

Fig. 3a Side Frame used on Un. Pac. Car having Nine Panels with Wood Posts and Braces; Posts Reinforced by Plate

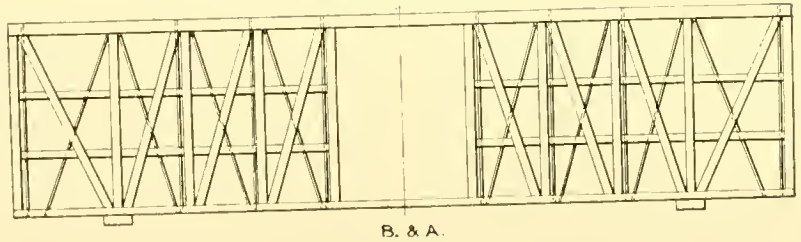


Fig. 4 Side Frame used on B. & A. Car having Nine Panels with Wood Posts and Diagonal Rod Bracing

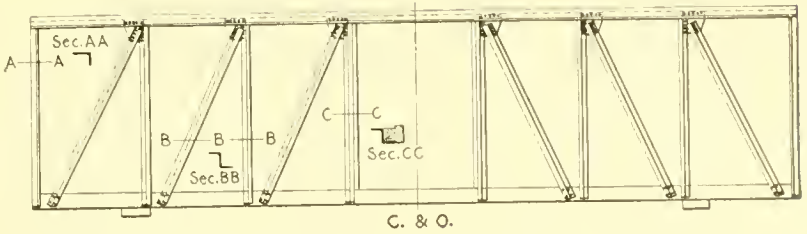


Fig. 5 Steel Side Framing used on C. & O. Car having Seven Panels with End Panel Braced Diagonally; Structural Material used

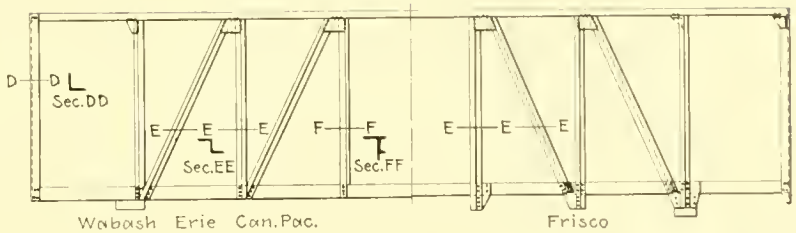


Fig. 6 Fig. 6a

Fig. 6 Steel Side Framing used on the Wabash, Erie and Can. Pac. Cars having Seven Panels and no End Panel Bracing; Structural Material used

Fig. 6a Steel Side Framing used on Frisco Car with Seven Panels and no End Panel Bracing; Structural Material used

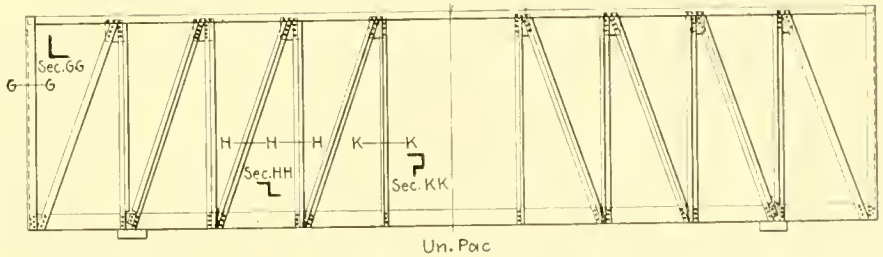


Fig. 7 Steel Framing used on the Un. Pac. Car having Nine Panels with End Panel Braced Diagonally; Side Door Posts Pressed Steel Section and Angle Iron

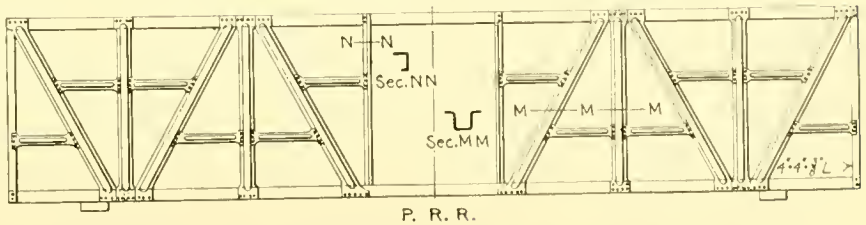


Fig. 8 Steel Side Framing used on P. R. R. Car with Seven Panels with End Panel Bracing from Bolster to Side Plate at End; Pressed Steel U-Sections with Flattened Ends for Securing to Side Plate and Side Sill

Table 8 Dimensions of running boards, type of roof and carline, width and height at eaves, etc.

Table 9 Distance between body bolsters, spread of truck wheels, etc.

Table 10 Dimensions of draft sills, side sills, floor supports, etc.

Table 11 Area, section moduli, etc., of steel underframes at center for cars with wood side frames

Table 12 Area, section moduli, etc., of steel underframes near bolster for cars with wood side frames

Table 13 Area, section moduli, etc., of steel underframes at center for cars with steel side frames

Table 14 Area, section moduli, etc., of steel underframes near bolster for cars with steel side frames

Table 1. By referring to this table, it will be noted that the inside dimensions, such as length and width for 36-ft. box cars are the same with but one exception—the inside height varies considerably, due to the type of the carline used. The American Railway Association adopted on October 23, 1901, standard inside dimensions for box cars as follows: length, 36 ft.; width, 8 ft. 6 in.; height, 8 ft. No recommendations were made by the Master Car Builders' Association, as requested by the American Railway Association, to establish external dimensions for the 36-ft. box car. By referring to the table it will be noted that the length over sheathing varies from 36 ft. 10¼ in. to 37 ft. 1⅛ in., with length over striking plates varying from 37 ft. 7⅝ in. to 38 ft. 8⅞ in., the variation being accounted for by the use of different types of end construction. No doubt these differences will continue on future designs of cars until a standard end frame and end sill construction is made compulsory.

TABLE 1 GENERAL DIMENSIONS OF BOX CARS WITH OUTSIDE SHEATHING

Road	Capacity	Light Weight of Car	Inside Dimensions			Length Over			Width Over Side Sills
			Length	Width	Height	Striking Plate	End Sill	Sheathing	
D. L. & W.	60,000	37,300	36′ 0″	8′ 6″	8′ 0″	37′ 7⅝″	*36′ 8⅝″	36′ 10¼″	9′ 0½″
C. R. R. of N. J.	60,000	39,000	36′ 0″	8′ 6″	8′ 0″	38′ 3½″	37′ 6½″	37′ 1⅛″	9′ 1″
P. & L. E.	80,000	39,600	36′ 0″	8′ 6″	8′ 4″	38′ 0½″	36′ 10¾″	37′ 0⅜″	9′ 2″
N. Y. O. & W.	80,000	40,000	36′ 0″	8′ 6″	8′ 2½″	38′ 8⅞″	37′ 10⅞″	36′ 11¾″	9′ 1⅝″
P. & R.	80,000	48,100	36′ 2″	8′ 7″	8′ 2⅛″	38′ 2½″	*37′ 0″	37′ 1¼″	9′ 2″
B. & Albany	80,000	39,800	36′ 0″	8′ 6″	8′ 4″	38′ 1″	36′ 10¾″	37′ 0⅜″	9′ 2″
C. & N. W.	80,000	41,200	40′ 0″	8′ 5¼″	7′ 11½″	41′ 10⅞″	40′ 9½″	40′ 11⅛″	9′ 1¼″
Un. Pac.	100,000	42,700	40′ 0″	9′ 1¾″	9′ 2¼″	42′ 1¼″	*40′ 8⅜″	40′ 9⅞″	9′ 8½″
C. & O.	80,000	39,700	36′ 0″	8′ 6″	8′ 0″	38′ 6½″	*37′ 10½″	36′ 11¼″	9′ 1⅝″

* Between End Sills.

Table 2. This shows similar dimensions for types of steel side frame cars, and it would appear that the inside dimensions, especially of the long cars, are made to suit the whims of various designers. There is really no excuse for such a condition, as it means a further drifting away from the car of standard dimensions which should by reason of duplication in all its parts, facilitate repairs, bearing in mind that it is going to be a more costly proposition for railroads to repair, and at times replace, parts of damaged superstructures of steel frame cars than when made of wood. It appears that there was a demand for larger cars than those adopted by the American Railway Association. At a meeting of this body held November 20, 1912, the Committee on Standard Dimensions for Box Cars, after ascertaining the clearances of various railroads, decided that a box car 40 ft. 6 in. long, 8 ft. 6 in. wide and 9 ft. high was the largest car which could be constructed with due regard for clearances. I believe it undesirable to increase the inside height of the car to 9 ft. on account of increasing the height of the center of gravity of the car from the top of the rail. The present inside cross dimensions should be maintained, and the car should simply be lengthened to 40 ft. in order to obtain increased cubic capacity. Attention is also called to the great variations in weight of cars shown in Tables 1 and 2, which leads me to believe that either some of the cars are built too light or others are carrying excess weight in the way of material not properly distributed.

Table 3. This table is very interesting in pointing out what various designers consider necessary in the way of sizes of material for posts and braces which make up the wooden body frame, the general arrangement of which is shown in Figs. 1 to 4. In 1904, the style of framing recommended by the Master Car Builders' Association, and shown in Fig. 2, was adopted for cars of 60,000 lb. capacity, and that shown in Fig. 3, for cars of 80,000 to 100,000 lb. capacity. There is this one exception, however, that the Master Car Builders' design indicates the use of one belt rail, whereas, it is now necessary to provide two belt rails in order properly to secure the outside sheathing. This extra rail also adds materially to the rigidity of the side frame, assisting it against end strains.

Table 4. In this table is shown a comparison on sizes of material used in different members of the steel frame box car. This type of framing, as applied to a large number of box cars recently constructed, lends itself very readily to standard construction; and it is well to note that, with the exception of intermediate posts and braces, we are again confronted with a va-

TABLE 2 GENERAL DIMENSIONS OF BOX CARS WITH INSIDE SHEATHING

Road	Capacity	Light Weight of Car	Inside Dimensions			Length Over			Width over Side Sills
			Length	Width	Height	Striking Plate	End Sill	End Posts	
Erie	80,000	38,800	36′ 0″	8′ 6½″	8′ 0½″	38′ 1¼″	*36′ 11½″	36′ 11½″	8′ 9½″
Can. Pac.	80,000	38,300	36′ 0″	8′ 6½″	8′ 0½″	38′ 1¼″	*36′ 11½″	36′ 11½″	8′ 9½″
Wabash	80,000	36,200	36′ 5⅝″	8′ 6″	8′ 0″	38′ 5⅝″	*37′ 4⅞″	37′ 4⅞″	8′ 9¼″
Frisco	80,000	40,700	40′ 0″	8′ 6″	8′ 0″	42′ 0¾″	*40′ 11″	40′ 11″	8′ 8¼″
Un. Pac.	100,000	41,800	40′ 5⅜″	9′ 2″	9′ 0″	42′ 1¼″	40′ 8¾″	41′ 4⅜″	9′ 5″
P. R. R.	100,000	47,900	40′ 6″	8′ 10″	8′ 0″	42′ 6″	42′ 6″	41′ 8½″	9′ 0½″

* Between End Sills.

riety of sections and weights of materials comprising the side plate, side sill, corner and door posts. There is no good reason why this condition should continue; these cars will be in service practically all over the country, and barring wrecks, the frames will be subject to the same stress due to impact blows, car lading and weight of superstructure.

The general designs of steel side frames are shown in Figs. 5 to 12. It will be noted that standard structural material has been used throughout, with the exception of the Pennsylvania Railroad box cars. The design of frame of this railroad, shown in Fig. 8, makes a splendid appearance, is well arranged and provides for vertical inside sheathing. Due to the construction of the posts and braces, slight contact blows from obstructions on neighboring tracks will not affect the appearance of the brace as they will if structural steel is used, which is more liable to distort. However, I am not in favor of pressed steel, on account of its higher first cost as compared with stock rolled steel and also of the fact that the ends of the posts and braces are flattened out where they connect to the side sill and plate, thus weakening them, especially at the bottom, where depth of the member is desirable to resist bending due to shifting of load or side impact blow.

I prefer the frame construction shown in Fig. 7 for cars having an inside length of 40 ft. or over and the same construction for cars 36 ft. inside length, omitting one panel from each side. A diagonal brace has been introduced in the end panel and is in tension due to lading, thus relieving the stress on the side sill near the bolster. It also ties the lower corner of the side frame. If the corner post were to receive an end blow directly over the push pole pocket, with the assistance of an end diagonal it would keep the panel square. Several designs (Figs. 6 and 6a) show omission of this brace, but for what reason I do not know, as it could be used to advantage also to secure the inside lining in this panel of wide span.

The question of frame design will depend largely on how the sheathing is to be extended, i. e., vertically or horizontally. The sheathing extends horizontally for all designs of steel frames shown, except for the pressed steel frame. I believe vertical sheathing is preferable as it protets the lading against water. In the case of horizontal sheathing, rain can beat in at the joints and the grooves or beading form gutters that have a tendency to deposit the water into the car, both at the door and end posts. This is an important question in the case of cars used for transporting grain. Standard size sheathing should also be adopted. Referring to the last column in Table 4, the thickness varies from 1¼ in. to 1⅝ in. and the width from 3¼ in. to 5¼ in. It is reasonable to assume that if all roads having cars built of this type were to use a uni-

TABLE 3 DIMENSIONS OF BODY SIDE FRAMING—WOOD CONSTRUCTION

Road	Capacity	Length over Sheathing	Side Posts	Side Braces	Side Plates	Corner Posts	Side Door Posts	Belt Rail		Style of Frame
								Size	No.	
D. L. & W.	60,000	36′ 10¼″	5″x2⅜″ with ⅜″x2¼″ Pl.	5″x2⅜″	6¼″x3¼″	5″x5″ with 3″x3″x $\frac{5}{16}$″ L.	5″x4¾″	4½″x2⅜″	2	Fig. 3
C. R. R. of N. J.	60,000	37′ 1⅛″	5″x2½″	5″x2½″	7½″x3″	4″—7½ lb. I 4″x5½″wood 2⅜″x4″filler	4½″x4⅜″	4″x3½″	2	Fig. 2
P. & L. E.	80,000	37′ 0⅜″	5″x3″	5″x3″	6″x4″	5½″x5½″	5½″x5 $\frac{1}{16}$″	4½″x3″	2	Fig. 1
N. Y. O. & W.	80,000	36′ 11¾″	5″x3″ and 3″—4 lb. [	5″x3″	7½″x4″	5″x5″	5½″x5″ and 3″—4 lb. [	3½″x3″	2	Fig. 2a
P. & R.	80,000	37′ 1¼″	6″x3⅜″	6″x2 $\frac{9}{16}$″	8″x3″	7¼″x7″	6″x4⅞″	6″x3⅜″	2	Fig. 2
B. & Albany	80,000	37′ 0⅜″	5″x3″	5″x3″	6¾″x4″	5½″x5½″	5½″x5½″	4½″x3″	2	Fig. 4
C. & N. W.	80,000	40′ 11¾″	5″x3¾″	5″x2¾″	6″x3″	6″x5½″	5″x4 $\frac{11}{16}$″	4″x2¾″	1	Fig. 3
Un. Pac.	100,000	40′ 9⅞″	5″x2½″ and ½″x2¼″ Pl.	5″x2½″	7″x3½″	5″x5″	6″x4¾″ and ½″x4½″ Pl.	4″x2½″	2	Fig. 3a

TABLE 4 DIMENSIONS OF BODY SIDE FRAMING—STEEL CONSTRUCTION

Road	Capacity	Side Sills	Length over End Posts	Side Posts	Side Braces	Side Plates	Corner Posts	Side Door Posts	Inside Sheathing	Size of Sheathing	Style of Frame
C. & O.	80,000	8″—11¼ lb. [5½″x3″ wood	36′ 9⅝″	3″—6.7 lb. Z	3″—6.7 lb. Z	3½″x3″x 5/16″∠ 2½″x5″ wood	4″x3″x 7/16″∠ 5″x4″ wood	3″—6.7 lb. Z 4¾″x3¾″ wood	Horizontal	13/16″x5¼″	Fig. 5
Erie	80,000	8″—11¼ lb. [flanges in	36′ 11½″	3″—6.7 lb. Z	3″—6.7 lb. Z 3 1/16″—8 4lb. Z	4″—8.2 lb. Z	5″x5″x⅜″∠	5″x3½″x 5/16″∠ with 3″—4 lb.	Horizontal	1½″x5¼″	Fig. 6
Can. Pac.	80,000	8″—11¼ lb. [flanges in	36′ 11½″	3″—6.7 lb. Z	3″—6.7 lb. Z 3 1/16″—8 4lb. Z	4 1/16″—10.3 lb Z	5″x5″x⅜″∠	5″x3½″x 5/16″∠ 3″—4 lb	Horizontal	1½″x5″	Fig. 6
Wabash	80,000	8″—11¼ lb. [flanges in	37′ 4⅞″	3″—6.7 lb. Z	3″—6.7 lb. Z	3″—6.7 lb. Z	4″x4″x¼″∠	3″—6.7 Z	Horizontal	1⅝″x5¼″	Fig. 6
Frisco	80,000	5″x3″x⅜″∠ 3″x4⅝″ wood	40′ 11″	3″—6.7 lb. Z	3″—6.7 lb. Z 3 1/16″—8 4lb. Z	4″x3″x 5/16″∠	5″x4″x⅜″∠	4″—8.2 lb. Z	Horizontal	1½″x3¼″	Fig. 6a
Un. Pac.	100,000	9″—13¼ lb. [flanges in	41′ 4⅜″	3″—6.7 lb. Z	3″—6.7 lb. Z	4″—8.2 lb. Z	5″x5″x⅜″∠	5″x3½″x 5/16″∠ Pressed U shape	Horizontal	1½″x5¼″	Fig. 7
P. R. R.	100,000	6″x4″x⅜″∠	41′ 8½″	¼″ Pl. Pressed U shape	¼″ Pl. Pressed U shape	4″x6″x⅜″∠	4″x4″x⅜″∠	Bulb Angle	Vertical	1¼″x3¼″	Fig. 8

form size of material, it would be far easier and cheaper to make repairs.

Table 5. This shows the various sizes of material used in end frame construction for cars with wood side frames. Various designs have been introduced, which are shown in Figs. 13 to 19. The use of I-beam posts seems to predominate, using wood fillers on each side for securing the belt rails; this forms an ideal construction when the posts are well secured to malleable iron pockets at top and bottom, in connection with a heavy end plate and with bottom pockets riveted to the end sill cover plate. Braces have also been introduced extending, as a rule, from the end sill corner to the end plate adjacent to the posts. No doubt this location is preferable on cars with wood framing on account of the practice of extending the side brace in end panel from the bolster to the top of the corner post.

For securing the end frame against movement at the bottom, due to shocks occasioned by the shifting of loads, an arrangement of angle irons, located on and extending across the top of the end sill and secured by rivets to the top plate, appears to be excellent. This angle iron is placed directly against the posts or sheathing. The former practice is preferable but it is necessary to cut out the sheathing at the bottom where it laps over the angle iron. Steel plates are also being introduced on the inside of box cars as shown in Fig. 17, this plate extending from the floor line to the top of the upper belt rail and well secured to the corner posts by metal bands, which extend back to the door posts. It will be noted that in this construction the end posts are of wood and braced on the outside of sheathing by two pressed steel braces extending across the car, secured to the corner posts. This arrangement was recommended by the Master Car Builders' Committee on Car Construction as a desirable method for rebuilding the ends of wooden cars with Master Car Builders' lining.

It is a known fact that cars built some ten or fifteen years ago were fitted up with a type of end framing which was very light in construction. No post or brace pockets were used in some cases, and in other cases where pockets were used, the metal re-inforcement of the wood posts, such as channels, etc., did not extend into the pocket. When these ends were changed over to that shown in Figs. 14 and 16, with 1¾ in. end lining, no further trouble was experienced. From my

TABLE 5 DIMENSIONS OF END FRAMING FOR CARS WITH WOOD SIDE FRAMING

Road	End Sills	End Plates	End Posts	End Braces	Corner Posts	Type of Frame
D. L. & W.	9″—15 lb. [flanges out; also 3″x3″x 5/16″∠ inside	3½″x11¾″	2—5″x3⅜″ reënforced with 3″x3″x 5/16″ ∠	5″x3⅜″	5″x5″ with 3″x3″x 5/16″∠	Fig. 19
C. R. R. of N. J.	12″—40 lb. [, flanges in ¼″x10″ Pl. & 3″x2½″x 5/16″∠ top	4″x13½″	4″—7½ lb. I with 2—2⅜″x4″ fillers	4″x4″	4″—7½ lb. I 4″x5½″wood 2⅜″x4″filler	Fig. 16
P. & L. E.	⅜″x10¾″ Pl. 4″x4½″x⅜″ ∠ top 3″x3″x⅜″∠s top and bott. inside	4″x12″	4″—7½ lb. I with 2—2″x4″ fillera	5″x4″	5½″x5½″	Fig. 13
N. Y. O. & W.	12″—20.5 lb. [flange in ¼″x12″top Pl. 3″x2½″x¼″∠ top	4″x13″	4″—7½ lb. I with 1—4″x2½″ wood filler	4″x4″	5″x5″	Fig. 14
P. & R.	13″—32 lb. [flanges out & cast iron filler 3″x2″x 5/16″∠ top	4″x15¼″	6″x4″ with 3/16″x6′—1¾″ Plate	None	7¼″x7″	Fig. 17
B. & Albany	½″x10″ Pl. 5″x3½″x⅜″∠top 3″x3″x⅜″∠s top and bott. inside	4″x12″	4″—7½ lb. I with 2—2 7/16″x4″ fillers	5″x4″	5½″x5½″	Fig. 13
C. & N. W.	6″x9¼″ wood with ½″x9″ Plate in rear	3″x14⅛″	5″—9¾ lb. I with 2—3⅛″x5″ fillers	5″x3″	6″x5½″	Fig. 15
Un. Pac.	8″—13¾ lb. [flanges out 3½″x3″x 5/16″∠ top inside and 5″x5 1/16″ wood	3⅜″x13″	5″x4⅜″ with ½″x3½″ flitch plate	5″x3⅜″	5″x5″	Fig. 18

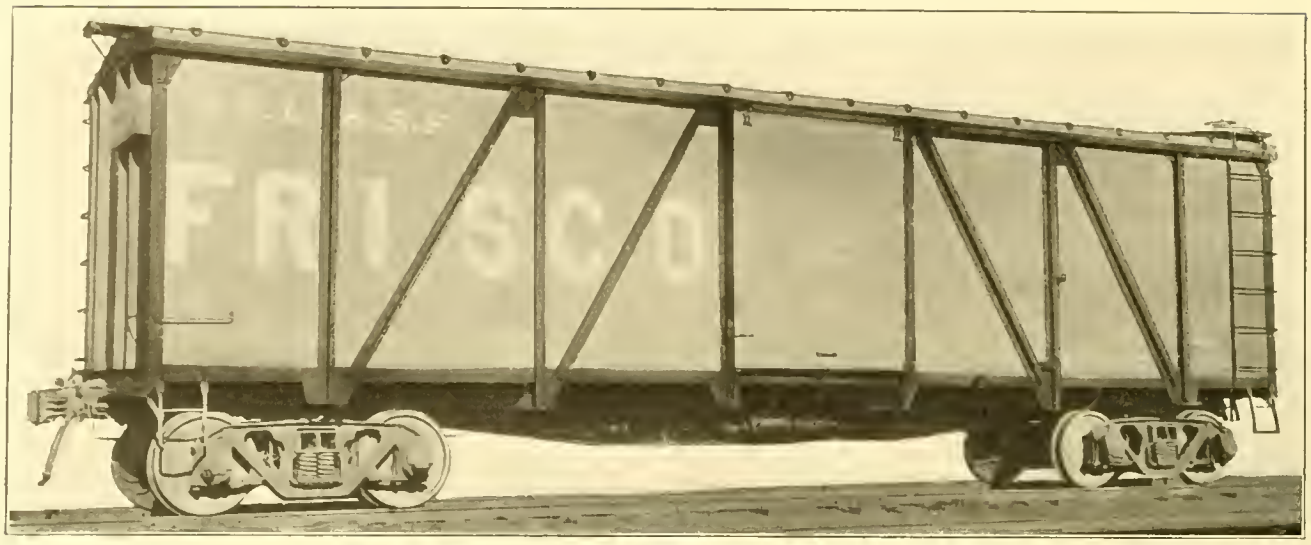


Fig. 9 40-Ton Outside Steel Frame Box Car used on Frisco System

personal experience, therefore, I do not believe an all-steel end is necessary to apply to wood side frame box cars.

Table 6. This shows various sizes of material used in end frame construction for cars with steel side frames, and the arrangements of posts and braces are shown in Figs. 20 to 25. Referring to Fig. 23, it will be noted that the diagonal brace has been omitted from the side panels; the brace has also been omitted from the end panel on the side frame and due to absence of both braces, especially the latter, I am of the opinion that the corners of the car are not sufficiently supported, and a side blow on the corner post near the eaves will result in distortion of the entire end of car. My attention was recently called to a car with end posts arranged as shown in Fig. 22; this car had received a side blow at the point in question and the entire end frame at the top took a permanent set of 4 in. from the vertical. For this reason, I believe diagonal braces extending from the side plate to the end sill near the center of car is a very desirable feature.

Z-bars appear to be well adapted for end posts and braces, and where set behind the end sill the best results will be obtained against strains due to end load shifting, as the entire section of metal in the Z-bar is subjected to shear. In this case it would appear desirable to use channel end sills with steel cover plate. By referring to Table 6, the variety of material used in the making of end sills may be noted. Here is where a standard construction could be made up along with striking plate, push pole pockets, corner post angles, etc., to advantage. Cars with inside sheathing should have end sills designed on standard lines, as it is a part of the car constantly requiring attention, especially in the vicinity of the end sill striking plate.

Referring to Fig. 25, the end construction for new cars as recommended by the Master Car Builders' Car Construction Committee may be noted. This design is evidently worked up on lines similar to those applied to the recent design of Pennsylvania box cars as shown in Fig. 24, the difference being in the use of rolled steel instead of pressed steel. I would hesitate to apply this construction to a new car, as I believe a good connection can not be made to the top of the end sill of the

TABLE 6 DIMENSIONS OF END FRAMING FOR CARS WITH STEEL SIDE FRAMING

Road	End Sills	End Plates	End Posts	End Braces	Corner Posts	Section Moduli of Posts and Braces	Type of Frame
C. & O.	8"—11¼ lb. [flanges out ¼"x14" top plate	4"x12" wood 4"—5¼ lb. [at bottom	2—4"—7½ lb. I with 1—3¾"x 13/16" and 1—2½"x4" fillers	2—4"—8.2 lb. Z	4"x3"x 7/16"∠ 5"x4" wood	12.28	Fig. 20
Erie.	10"—15 lb. [flanges out ¼"x12" top cover Plate	Pressed steel Z shape	2—4"—8.2 lb. Z	None	5"x5"x⅜"∠.	6.28	Fig. 23
Can. Pac.	10"—15 lb. [flanges out ¼"x12" top cover Pl.	Pressed steel Z shape	2—4"—8.2 lb. Z	None	5"x5"x⅜"∠	6.28	Fig. 23
Wabash.	8"—13¾ lb. [flanges out ¼"x12" top cover Pl.	Pressed steel Z shape 7/16"	2—4"—8.2 lb. Z 2—3"—6.7 lb. Z	None	4"x4"x¼"∠	10.12	Fig. 22
Frisco	8"—11¼ lb. [flanges out ¼"x12" top cover Pl.	Pressed steel Z shape	2—4"—8.2 lb. Z 2—3"—6.7 lb. Z	None	5"x4"x⅜"∠	10.12	Fig. 22a
Un. Pac.	9"—13¼ lb. [flanges in ¼"x8" top cover Pl.	5"x3"x 5/16" ∠	2—4"—8.2 lb. Z	2—4"—7¼ lb. [	5"x5"x⅜"∠	6.98	Fig. 21
P. R. R.	Pressed steel Z shape upper leg 23⅝", lower leg 5⅛"	Pressed steel	1 Pressed steel U shape	2 Pressed steel U shape	4"x4"x⅜"∠	14.94	Fig. 24

Fig. 10. 40-Ton Outside Steel Frame Box Car used on Wabash R. R.

single post and two braces as shown. Again, this framing is not adapted to the application of end doors, which a good many roads find it desirable to apply on account of the loading of lumber, rails, etc. My preference is for a similar structure, using two posts, instead of one, with a diagonal brace each side similar to Fig. 20, having all posts and braces pass below the top of the end sill, for the reasons already mentioned. The short vertical plate behind the posts is desirable, and along with the wood lining, should make a practical arrangement.

Table 7. This table gives the sizes of door openings and sizes of doors used on recently constructed box cars. Of all the things which should be made standard, a box car side door is one of the most important. The Master Car Builders' Association now has a door standard, 6 ft. 5 in. wide and 8 ft. high, and it is endeavoring to make this standard for new as well as old equipment. How many railroads are following this practice, which was recommended by their committee in 1910 and adopted as standard in 1912? By consulting this table, it will be noted that but one railroad, the New York, Ontario & Western, has applied doors of this size.

It has been the practice to use door hangers with rollers, in order to permit the door to slide easily. Some cars were recently constructed with heavy doors, but rollers were omitted from the hangers, and I have learned from good authority that they are not satisfactory, as a great deal of exertion is required to operate them. My recommendation is to continue the use of hangers with rollers. Also sufficient number of door guides, as recommended by the Master Car Builders' Association, is not being applied; they are safeguards

TABLE 7 DIMENSIONS OF SIDE DOOR OPENINGS, SIZE OF DOOR AND DISTANCE FROM RAIL TO TOP OF FLOOR

Road	Distance from Rail to Top of Floor	Side Door			No. of Door Guide Brackets
		Opening	Size	Type	
D. L. & W.	4′ 0½″	6′ 0″x7′ 6½″	6′ 6″x7′ 11½″	M. C. B.	2
C. R. R. of N. J.	3′ 8″	6′ 0″x7′ 6½″	6′ 5½″x7′ 10⅝″	M. C. B.	4
P. & L. E.	4′ 0″	6′ 0″x8′ 0 9/16″	6′ 6¾″x8′ 2½″	M. C. B.	4
N. Y. O. & W.	4′ 1⅛″	6′ 0″x7′ 8″	6′ 5″x8′ 0″	M. C. B.	3
P. & R.	3′ 7⅞″	6′ 0″x7′ 6¾″	6′ 6½″x8′ 2½″	Square Frame	5
B. & Albany	4′ 0″	6′ 0″x8′ 0″	6′ 6¾″x8′ 2½″	M. C. B.	4
C. & N. W.	4′ 1⅛″	5′ 0″x7′ 5½″	5′ 2⅝″x7′ 8″	Not M. C. B.	1
Un. Pac.	3′ 9 13/16″	6′ 0″x8′ 8⅞″	6′ 6¾″x9′ 1″	M. C. B.	4
C. & O.	3′ 11 13/16″	5′ 6″x7′ 6¼″	5′ 9″x7′ 9½″	Square Frame	2
Erie	4′ 1″	6′ 0 1/16″x7′ 7 3/16″	6′ 3¼″x7′ 8 13/16″	M. C. B.	4
Can. Pac.	4′ 2¼″	5′ 0″x7′ 8″	5′ 4¾″x7′ 10⅛″	M. C. B.	2
Wabash	4′ 0¼″	6′ 0″x7′ 7¾″	6′ 5″x7′ 10¾″	M. C. B.	2
Frisco	4′ 1″	6′ 0″x7′ 7⅜″	6′ 7 3/16″x7′ 9 13/16″	Not M. C. B.	4
Un. Pac.	3′ 9 11/16″	6′ 2″x8′ 7″	6′ 6⅜″x8′ 9 3/16″	M. C. B.	4
P. R. R.	3′ 7½″	6′ 0″x7′ 3⅝″	6′ 3⅞″x7′ 9¾″	⅛″ Steel	2

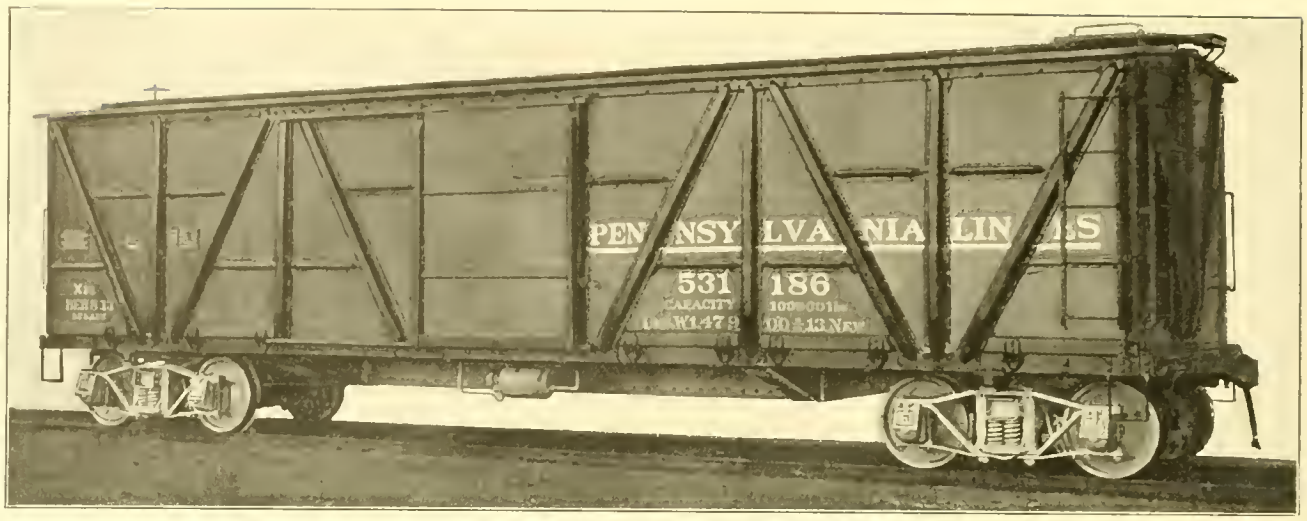


Fig. 11. 50-Ton Outside Steel Frame Box Car used on P. R. R.

against accident if a door hanger should fail, and four guides should be applied as required.

The height from rail to top of floor shown in Table 7 varies somewhat from the Master Car Builders' standard of 4 ft. There is no reason for this oversight on the part of motive power officials, and it is of considerable importance as it permits of standard unloading platform heights all over the country, making it easier for electric freight handling trucks to enter the cars on the same level.

Table 8. This table gives some idea of the variety of roofs and roof carlines applied to recent box cars. The number of carlines required seems to be a disputed matter and evidently has been left to the manufacturer who supplies the roof. The essential requirements for a carline are to support the weight of the roof, with a suitable allowance for additional loading due to accumulation of snow and ice, and which is of equal importance, to prevent the sides of the car near the eaves from spreading due to lading.

As car roofs are now receiving considerable attention by motive power officials, I will describe the various types in use. They are usually divided into three classes, known as inside roofs, outside roofs, and all-steel roofs. The classification, inside roof, covers all types of car roofs where the metal is inside of the car, and the roof boards over this metal are on the outside of the car. The classification, outside metal roof, covers car roofs where the steel is on the outside of the car, and the roofing boards are underneath. The classification, all-steel roof, covers a car roof in which a heavy sheet is used, usually about 16 U. S. gage material. In this case, no roof boards are used, either above or under the roofing sheets.

The inside metal roof is the oldest type of roof in service. The original freight car roof consisted of either single or double sheathing of boards on top of the car, but the strain on these roofs was such that they could not be kept without continual repairs. The inside metal roof was then developed and being made of separate flexible units, permitted weaving of the car to take place and still have a waterproof roof be-

TABLE 8 DIMENSIONS OF RUNNING BOARDS, TYPE OF ROOF AND CARLINES, WIDTH AND HEIGHT AT EAVES, ETC.

Road	Type of Carline	No. of Carlines	Type of Roof	Max. Width over Eaves	Distance, Rail to Eaves	Running Board		
						Width	Size of Matl.	Length
D. L. & W.	Pressed Steel U; also ⊓	7	Inside and all Steel	9′ 7″	12′ 5½″	19″	1⅛″x6″	38′ 2¼″
C. R. R. of N. J.	Pressed Steel	7	Inside Metal	9′ 6¾″	12′ 2⅞″	19″	1″x6″	38′ 6″
P. & L. E.	Rolled Steel	11	All Steel	9′ 5½″	12′ 6½″	20″	1″x6″	38′ 3¼″
N. Y. O. & W.	Pressed Steel [	11	All Steel	9′ 6″	12′ 5½″	24″	1″x7½″	38′ 8″
P. & R.	Pressed Steel U	8	Inside Metal	9′ 10″	12′ 1¾″	19″	13/16″x5¾″	38′ 7″
B. & Albany	Pressed Steel [	8	Outside Metal	9′ 5 7/16″	12′ 7⅛″	20″	1″x6″	38′ 3″
C. & N. W.	⅜″x3″ Plate; 3″x3″ wood	12	Inside Metal	9′ 9″	12′ 5⅞″	18½″	1¼″x6″	41′ 10″
Un. Pac.	4″x2″x¼″ ∠; 1⅞″x9¾″ wood	9	Outside Metal	10′ 1″	13′ 4 7/16″	24″	1⅛″x7½″	42′ 5″
C. & O.	3″x3″x¼″ ∠ and wood	7	Outside Metal	9′ 7½″	12′ 4″	24″	1″x7½″	38′ 3⅝″
Erie	Pressed Steel [	8	Inside Metal	9′ 3⅛″	12′ 6 11/16″	19″	1¼″x6″	38′ 5½″
Can. Pac.	Pressed Steel [	8	Inside Metal	9′ 3½″	12′ 7 9/16″	24″	⅞″x7½″	38′ 5½″
Wabash	Pressed Steel ⊓	11	All Steel	9′ 10½″	12′ 0½″	18¾″	⅞″x5¾″	38′ 7″
Frisco	4″—9½ lb. I	8	Outside Metal	9′ 7⅛″	12′ 5⅝″	18″	1⅛″x5¾″	42′ 1″
Un. Pac.	3″x3″x¼″ ∠, and wood	9	Outside Metal	9′ 8″	13′ 1 9/16″	24″	1⅛″x7½″	42′ 5″
P. R. R.	Pressed Steel U	10	⅛″ Steel Plate, riveted	9′ 11 11/16″	11′ 8″	18⅛″	1½″x5¾″	42′ 11½″

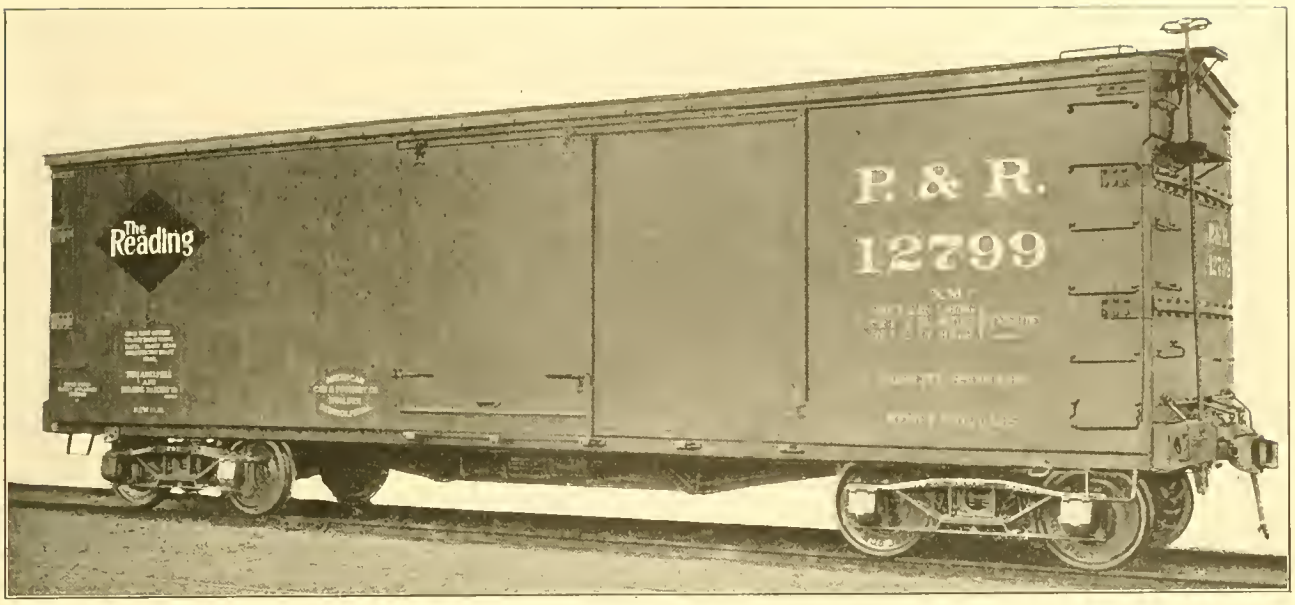


Fig. 12 40-Ton Steel Underframe Box Car used on P. & R. Ry.

low the roof boards. The outside roof boards are simply a protection to keep the trainmen from walking on the roofing sheets. The advantages of the inside type are: (*a*) flexibility, (*b*) protection of the metal from the weather, (*c*) protection of the metal from trainmen's boots, and (*d*) prevention of the quick corrosion of the metal, due to the roof boards preventing a deposit of cinders on the metal, which, when attacked by moisture, quickly eats away the galvanizing and also the sheet itself.

The objections raised against this type are that the outside roofing boards work loose, the torsional strains of the car causing the nails to work out and rust off. This condition is usually caused by the weaving of the car superstructure and can be eliminated to some extent by the use of stronger carlines. An inside roof properly applied as far as the metal is concerned, should last a good many years, with the replacement of the roof boards about every four years. These roof boards, besides being secured by nails, are now held down at the eaves by wire staples locking the boards to the facia.

Of the outside metal roofs, there are numerous types on the market, but in a general way they are similar. Their differences usually are in the method of fastening the sheets at the eaves. The gage of metal ranges in most cases from 22 to 26 U. S. The advantages claimed for the outside metal roofing are: (*a*) ease of application, (*b*) ease of repair, (*c*) somewhat lower first cost, and (*d*) possible prevention of fires, particularly in the west.

The objections which develop in this type of roof have been: the exposure of the metal itself to weather and chafing of the sheets where joined, causing the galvanizing to wear off so that the sheet quickly rusts. Cinders also collect along the eaves where castings are used, and when wet, sulphuric acid action will set in and eat out the sheet. This is partially overcome by the use of a slip joint along the eaves as provided for on the later types.

The all-steel type of roof is a development of the last three or four years, and consists of metal plates of about 16 U. S. gage resting on steel carlines, they being an integral part of the roof. In some cases the sheets extend from side to side of the car, and in others

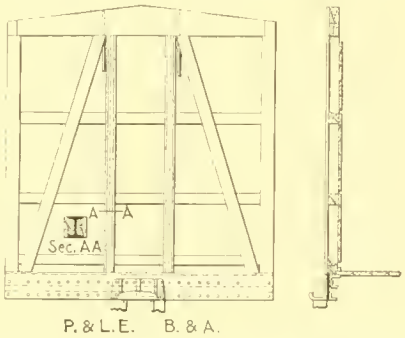


Fig. 13 End Framing used on P. & L. E. and B. & A. Cars showing I-Beam End Posts with Wood Fillers and Diagonal Braces Extending from End Sill to End Plate at Center Posts

the sheets are divided extending from the eaves to the ridge pole. The amount of galvanizing used on these sheets is practically the same as that on the outside metal roofs, which is about 1.8 oz. per sq. ft. on both sides of the sheet. The claim is made that this type somewhat lightens the weight of the car, but the same objections have been raised regarding the wearing out of the material as well as the tearing of the metal due to its rigid application. This latter feature is now receiving some attention by the manufacturers, and no doubt can be overcome. This style of roof is more expensive than the other types previously mentioned.

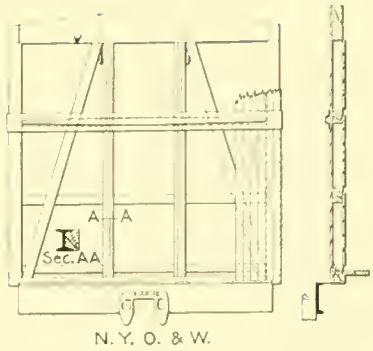


Fig. 14 End Framing used on N. Y. O. & W. Car having I-Beam End Posts with Wood Fillers; Diagonal Braces Extending from End Sill to End Plate at Center Posts and One Pressed Steel Horizontal Brace

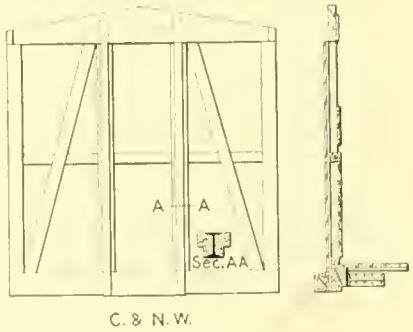


Fig. 15 End Framing used on C. & N. W. Car with I-Beam End Posts having Wood Fillers; Diagonal Braces extend from Sill to End Plate at Center Posts

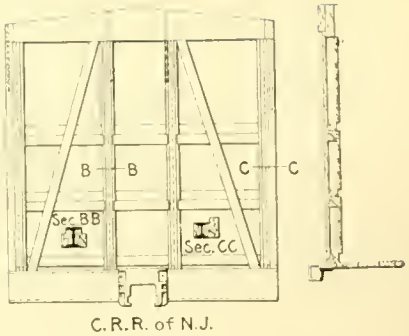


Fig. 16 End Framing used on C. R. R. of N. J. Car having I-Beam Center and Corner Posts with Wood Fillers; Diagonal Braces extend from End Sill to End Plate at Center Posts

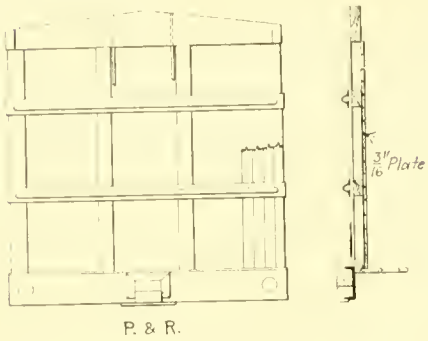


Fig. 17 End Framing used on P. & R. Car with Wood Center Posts; Plate Reinforcement and 3/16-inch End Surfacing Plate; Two Pressed Steel Horizontal Braces

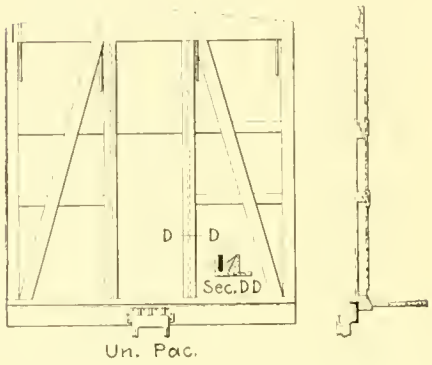


Fig. 18 End Framing used on Un. Pac. Car with Center Posts consisting of Wood and Plate Reinforcement; Diagonal Braces extending from End Sill to End Plate at Center Posts

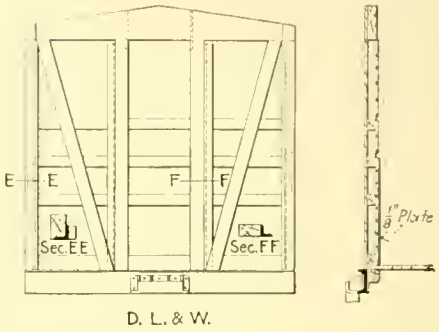


Fig. 19 End Framing used on D. L. & W. Car showing Center and Corner Posts made up of Angle Iron and Wood Fillers; Diagonal Braces run from End Sill at Center Posts to End Plate at Corner Posts 1/8-In. End Reinforcing Plate

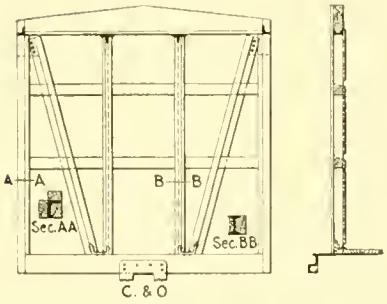


Fig. 20 Steel End Framing used on C. & O. Car with I-Beam Center Posts; Diagonal Braces run from End Sill at Center Posts to End Plate

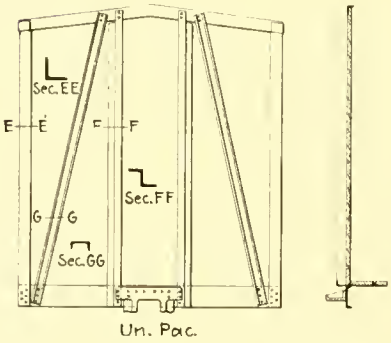


Fig. 21 Steel End Framing used on Un. Pac. Car with Z-Bar Center Posts; Channel Braces run from End Sill to End Plate at Center Posts

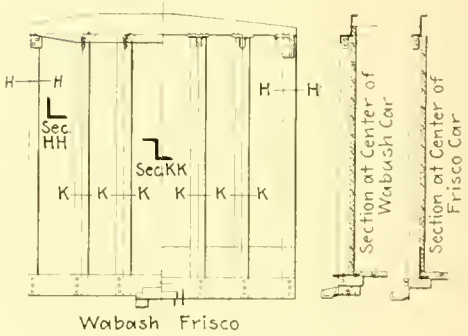


Fig. 22 Steel End Framing used on Wabash and Frisco Cars with Z-Bar Center and Intermediate Posts; no Diagonal Braces

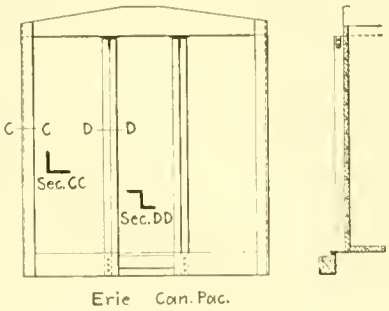


Fig. 23 Steel End Framing used on the Erie and Can. Pac. Cars with Z-Bar Center Posts; No Diagonal Braces

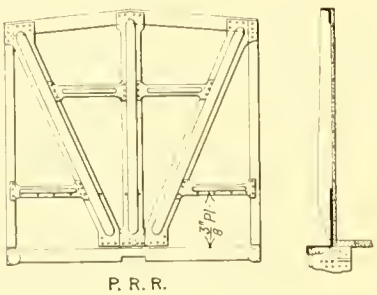
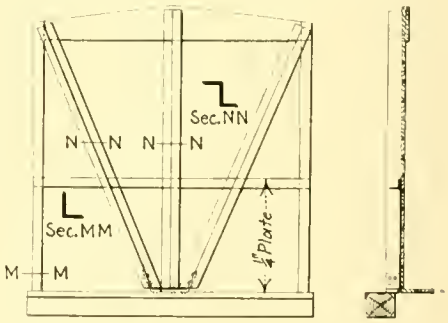


Fig. 24 Steel End Framino used on P. R. R. Car with Pressed Steel U-Sections; Diagonal Braces run from End Sill at Center Posts to End Plate and 3/8-In. End Reinforcing Plate at Bottom



Fio. 25 Steel End Framing, M. C. B. Recommended Design with Single Z-Bar Center Post; Diagonal Braces run from End Sill at Center to End Plate and 1/4-In. End Reinforcing Plate at Bottom

FIG. 26 40-TON STEEL UNDERFRAME BOX CAR USED ON C. & N. W. LINE

Large sums of money are paid out annually by our railroads to cover damage claims due to wet lading and the roof problem is a severe one with us. The service requirements, due to the use of heavy power and the severe service that cars are receiving in freight classification yards, compel us to give this matter our earnest attention and assist the manufacturers of car roofs as much as possible in developing a roof that, with ordinary care, will stay tight and protect the lading. Considerable success has been obtained with roofs applied to box cars made up of inside and outside roof boards, having a layer of waterproof roofing material between the boards, similar to that applied to refrigerator cars.

In the application of running boards, there seems to be no standard method followed. Table 8 shows that the width over all varies from 18 in. to 24 in. and size of material from 7/8 in. to 1 1/4 in. thick and in widths from 5 3/4 in. to 7 1/2 in. This does not appear on the surface to be a very important matter, but it seems to me that a better understanding should have existed between railroads, at least to arrive at a standard width of platform for the safety of trainmen and standard size of materials. The Interstate Commerce Commission recommends a standard width of 20 in. and allows a minimum of 18 in. I would suggest, therefore, that all railroads, when applying new running boards to old or new equipment, construct the platform 20 in. wide using 1 1/8 in. by 6 1/4 in. material.

Table 9. This table shows the spread of body bolsters for box cars of different inside lengths, also distance over striking plates, truck wheel centers, etc. For cars 36 ft. inside length, bolster centers vary from 26 ft. 6 in. to 27 ft. 6 in. and for the longer car this variation is shown from 30 ft. 6 in. to 32 ft. 6 in. The effect of a long overhang of the car from the center

TABLE 9 DISTANCE BETWEEN BODY BOLSTERS, SPREAD OF TRUCK WHEELS, TYPE OF TRUCK FRAMES, BOLSTERS, ETC.

Road	Inside Length	Length over Striking Plate	Truck				
			Centers	Wheel Base	Type of Frame	Type of Bolster	Kind of Wheels
D. L. & W.	36′ 0″	37′ 7 5/8″	27′ 0″	5′ 0″	Arch Bar	Cast Steel	Cast Iron
C. R. R of N. J	36′ 0″	38′ 3 1/2″	27′ 0″	5′ 6″	Arch Bar	Cast Steel	Cast Iron
P. & L. E.	36′ 0″	38′ 0 1/2″	27′ 0″	5′ 6″	Cast Steel	Steel Built up	Cast Iron
N. Y. O. & W.	36′ 0″	38′ 8 7/8″	26′ 6″	5′ 6″	Cast Steel	Cast Steel	Cast Iron
P. & R.	36′ 2″	38′ 2 1/2″	27′ 6″	5′ 6″	Arch Bar	Steel Built up	Cast Iron
B. & Albany	36′ 0″	38′ 1″	27′ 0″	5′ 6″	Cast Steel	Steel Built up	Cast Iron
C. & N. W.	40′ 0″	41′ 10 7/8″	30′ 6″	5′ 0″	Arch Bar	Steel Built up	Cast Iron
Un. Pac.	39′ 11 7/8″	42′ 1 1/4″	30′ 8″	5′ 6″	Cast Steel	Steel Built up	Cast Iron
C. & O.	36′ 0″	38′ 6 1/2″	26′ 10″	5′ 6″	Arch Bar	Cast Steel	Cast Iron
Erie	36′ 0″	38′ 1 1/4″	26′ 10″	5′ 4″	Cast Steel	Steel Built up	Cast Iron
Can. Pac.	36′ 0″	38′ 1 1/4″	26′ 10″	5′ 4″	Arch Bar	Steel Built up	Cast Iron
Wabash	36′ 5 5/8″	38′ 5 5/8″	27′ 2″	5′ 4″	Arch Bar	Steel Built up	Cast Iron
Frisco	40′ 0″	42′ 0 3/4″	31′ 0″	5′ 6″	Cast Steel	Cast Steel	Cast Iron
Un. Pac.	40′ 5 3/8″	42′ 1 1/4″	30′ 8″	5′ 6″	Cast Steel	Steel Built up	Cast Iron
P. R. R.	40′ 6″	42′ 6″	32′ 6″	5′ 6″	Arch Bar	Cast Steel	Rolled Steel

line of the bolster to the pulling face of the coupler has a tendency to cause derailment on curves, due to the coupler side clearance in the striking plate not being sufficient to permit the coupler to swing over when the car is coupled with another car that has a short overhang; if derailment does not occur, excessive wheel flange wear is produced. For 36 ft. box cars it would appear desirable to have the bolster centers made 27 ft. which is now standard on a large number of railroads and allows ample space for the application of draw gear.

For longer cars the same overhang as obtained under the above conditions for 36 ft. cars could be maintained, which would make the bolster centers 31 ft. for a car 40 ft. long inside. The distance from the face of the striking plate to the outside face of the body end construction should be ample to permit of the proper clearances being maintained for safety appliances, as required by law.

Truck wheel centers vary somewhat, the majority of the railroads now using trucks with wheels spaced 5 ft. 6 in. apart. This I consider very good practice, as it allows ample room for inside brake rigging. Truck arch bars and cast-steel side frames should be designed to interchange with one another and should conform to the Master Car Builders' requirements. The practice of using various designs of cast-steel side frames which vary in details should be discouraged, as there is no reason why a standard design of truck side frame for the different capacity cars should not be obtained and applied by every railroad in the country. This certainly would simplify repairs and they could then be purchased in the open market subject to specifications.

Bolster designs should also be made standard. This is a very important matter as the life of truck bolsters made of cast steel is uncertain, a number being replaced within five to ten years after cars are placed

TABLE 10 DIMENSIONS OF DRAFT SILLS, SIDE SILLS, FLOOR SUPPORTS, ETC.

Road	Side Sills	Draft Sills	End Sill Diagonal Brace	Body Bolster			Cross Bearer				Floor Beams	
				Type	Plates		Type	Plates		Spacing Ctr to Ctr.	Type	No.
					Top	Bottom		Top	Bottom			
D. L. & W.	8"—11¼ lb[with 3"x3½"x 5/16" ∠ 3¾"x4⅜" wood	12"—25lb.[	4"—8.2 lb.Z	Pressed Steel][	½"x20½"	⅜"x10"	Cast Steel	5/16"x7"	5/16"x6"	7' 0"	4"—8.2 lb.Z	3
C.R.R. of N.J.	12"—20½ lb. [3"x3½"x⅜"∠ 3¾"x4" wood	15"—33 lb.[	5"—6.5 lb.[	¼" Pressed Steel [s back to back	7/16"x17½"	7/16"x14"	¼" Pressed Steel [	⅜"x6"	⅜"x6"	9' 0"	6"—8 lb. [	3
N.Y.O.& W.	¼" Pressed Steel Z —9" high	⅜" Pressed Steel Z	5"—6.5 lb.[	¼" Pressed Steel][	⅜"x14"	½"x14"	¼" Pressed Steel [	¼"x6"	¼"x6"	8' 7"	¼" Pressed Steel [	3
P. & R.	10"—20 lb. [3"x3"x 5/16"∠ 3½"x4" wood	⅜" Pressed Steel Z spliced to ctr. sill	5"—9 lb. [	⅜" Pressed Steel [s back to back	½"x24"	¾"x16"	⅜" Pressed Steel [	½"x6"	⅝"x6"	9' 2"	5"—9 lb. [	3
B. & Albany	4"—8.2 lb. Z 4"x4" wood	⅜" Pressed Steel Z spliced to ctr. sill	5"x3"x 5/16" ∠	¼" Pressed Steel][	⅜"x15"	⅜"x15"	¼" Pressed Steel [	¼"x3½"	¼"x3¾"	9' 0"	Same as cross-bearer with cover Plates	3
C. & N. W.	6"—15.6 lb. Z	15"—33 lb.[	3½"x3½"x ⅜" ∠	¼" Pressed Steel][	⅜"x22½"	⅝"x15"	¼" Pressed Steel [	⅜"x5½"	⅜"x5½"	7' 8"	4"—9½ lb. I	8
Un. Pac.	5"—11.6 lb.Z with 3 15/16"x5½" wood	⅜" Pressed Steel spliced to ctr. sill	None	Cast Steel	.	. .	10"—25 lb. I	.	. . .	9' 0"	10"—25 lb.I	3
C. & O.	8"—11¼ lb. [5½"x3" wood	15"—33 lb.[	¼" Pressed Steel [5" wide	¼" Pressed Steel][	½"x12"	⅝"x12"	¼" Pressed Steel [	⅜"x6"	⅜"x6"	6' 6"	4"—5¼ lb.[	3
Erie	8"—11¼ lb. [flanges in	15"—33 lb.[	5"x3½"x⅜"∠	¼" Pressed Steel][	½"x15"	½"x15"	¼" Pressed Steel [	½"x6"	½"x6"	5' 3½"	4"—8.2 lb.Z	4
Can. Pac.	8"—11¼ lb. [flanges in	15"—33 lb.[	5"x3½"x⅜"∠	¼" Pressed Steel][	½"x15"	½"x15"	¼" Pressed Steel [	½"x6"	½"x6"	5' 5½"	4"—8.2 lb.Z	4
Wabash	8"—11¼ lb. [flanges in	⅜" Pressed Steel Z spliced to ctr. sill	4"x3"x¼"∠	¼" Pressed Steel][	⅜"x15"	⅜"x15"	¼" Pressed Steel [	⅜"x6"	⅜"x6"	9' 0"	¼" Pressed Steel [	3
Frisco	5"x3"x⅜" ∠ 3"x4⅝" wood	⅜" Pressed Steel Z spliced to ctr. sills	5"—6½ lb.	5/16" Pressed Steel][	⅜"x14½"	⅜"x18"	9"—15 lb.[	. .	. . . . .	6' 5¾"	9"—15 lb. [	2
Un. Pac.	9"—13¼ lb. [flanges in	¼" Pressed Steel outside angle No splice	None	¼" Pressed Steel][	⅜"x14"	⅜"x14"	¼" Pressed Steel [	¼"x6"	¼"x6"	9' 0"	¼" Pressed Steel [	3
P. R. R.	6"x4"x⅜" ∠	⅜" Pressed Steel No splice	Pressed Steel [8" wide	⅜" Pressed Steel U Shape	.	. . . . .	⅜" Pressed Steel][	⅜"x12"	⅜"x12"	17' 10"	Pressed Steel [¾" deep	6

in service. It would avoid unnecessary delay in obtaining new bolsters for repairs when replacing a built-up design, especially when changing from one manufacturer to another, who not having a bolster pattern that will interchange, will try to furnish something else or make new patterns and in the meanwhile cars are tied up at the repair shops. It is manifestly impossible to carry such parts in stock for five to ten different designs for the same capacity car, as this cannot be done without increasing the amount of stock 25 to 50 per cent over the present allowance.

Tables 11 to 14. These tables have been compiled to show interesting information on the subject of center sill constructions for 14 different cars, the types of underframes used in which are shown in outline in Figs. 27, 28 and 31. The heavy lines in the drawings indicate the cover plates used which appear to be a general practice among designers. This is considered by many to be a very desirable feature and besides adding to the rigidity of the structure, increases the net area of section and therefore reduces the fiber stress to within reasonable figures.

The strains which an underframe has to withstand vary, and depend a great deal on the design and arrangement of body bolsters, side sills and body framing. With substantial side sills and body bolsters, compressive strains can be transmitted by the latter and thus part of the compressive load can be taken care of by the side sills. However, there is a limit to the load the side sills can take care of which is based on the ratio of length to the least radius of gyration, the length being considered as the maximum distance between adjacent floor beams. In the case of cars with wood body side framing it would appear desirable to provide sufficient area at the smallest section of the center sills to take care of end strains, allowing the side sill to carry only its proportions of the vertical loads due to lading, weight of superstructure and an allowance for oscillation.

In the case of box cars with steel side frames there is no question about the ability of the frame structure to carry considerably greater loads, both vertically and due to end shock, on account of the diagonal braces assisting in transmitting the strain throughout the side. For this reason some designers do not consider it necessary to use continuous cover plates on the center sills, but use rolled steel sections for these sills, having a much smaller net area than what is considered good practice by others.

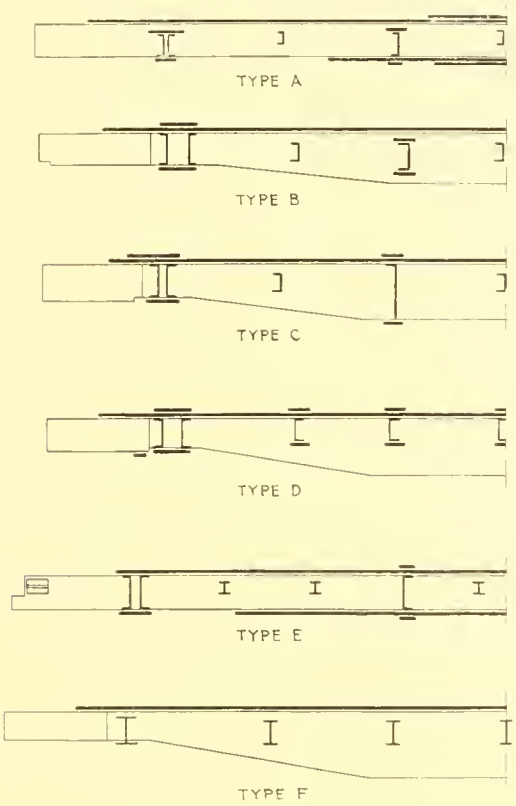


Fig. 27

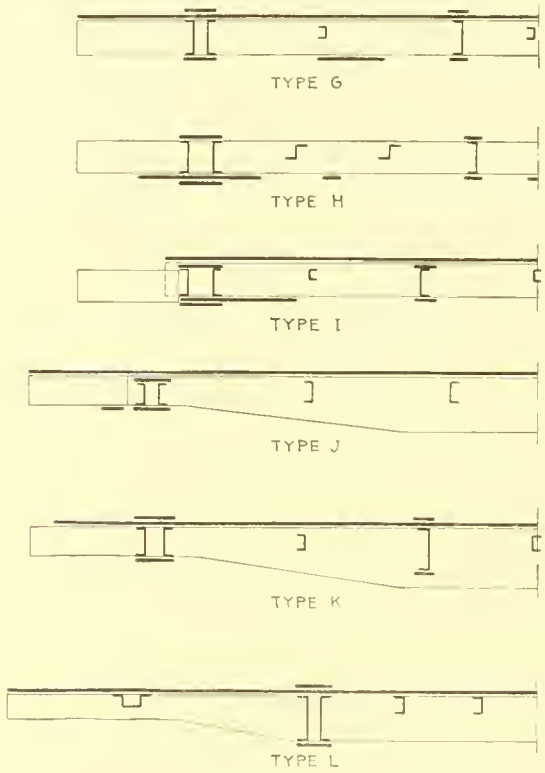


Fig. 28

Fig. 27 Types of Center Sills showing the Diversity in Design, Arrangement of Cross Bearers, Length of Cover Plates, Etc., as applied to Box Cars with Wood Side Frames

Fig. 28 Types of Center Sills showing the Diversity in Design, Arrangement of Cross Bearers, Length of Cover Plates, Etc., as applied to Box Cars with Steel Side Frames

In order to analyze properly the stresses in underframes a standard method of comparison should be made. Cars do not fail as a rule because of the weight of lading, but principally because of strains transmitted through the coupler. The magnitude of the end shocks that underframes have to withstand were investigated in tests conducted prior to 1902, on the

TABLE 11 CARS WITH WOOD SIDE FRAMES AT CENTER

Road	Sill Type	Section Type	Depth over Flanges, In	Web Plate, In.	Outside Top Angle, In.	Bottom Angle, In.		Cover Plate, In.		Min Area, S_t In	Neutral Axes		Section Moduli		Max Stress due to Vertical Loads, Lb. per Sq. In.	Compression due to End Shock, Lb. per Sq In.	Compression due to Eccentricity, Lb. per Sq In	Maximum Combined Compression Lb per Sq In	Center Line of Draw Gear above or below Neutral Axis, In.	$\frac{1}{A}+\frac{e}{S}$
						Outside	Inside	Top	Bottom		X_c	X_t	S_c	S_t						
D. L. & W	A	A	12		.			2-¼x19	2-¼x19	32.12	6 21	6.79	154 16	141.0	9851c 10770t	9338	6402	12787	3 29 below	0.054
C R. R of N J	A	A	15			.	.	1 ⅜x20½ 1-¼x20½	1 ⅜x20½ 1-¼x20½	36 23	7 67	8 20	209 55	196.0	7421c 7885t	8279	697	16401	.487 above	0.029
N Y O & W	B	G	21	¼	3⅞ ff'ge	3½x3x 7/16	3½x3x 7/16	¼x21¼	.....	27.67	12.74	11 51	212.57	235.28	8462c 7645t	10842	2455	21759	1 74 above	0.0442
P & R	C	E	26	⅜	4x4x½	4x4x½	4x4x½	¼x22½	.....	45 01	13.00	13 19	377.69	373.97	5514c 5569t	6664	5012	17190	6 31 above	0.038
B. & A	D	E	22	¼	3x3x⅜	3x3x⅜	3x3x⅜	¼x20¼	.....	26 84	10 18	12 07	213.67	180 21	8931c 10590t	11177	3410	23519	2 13 above	0.0485
C. & N W.	E	B	15	.	.. ..	.....	.....	⅜x20	⅜x20	33 12	7.51	8 24	188 57	171.86	11859c 13012t	9050	7143	13772	4 19 below	0.058
Un Pac	F	E	30½	¼	3x3x 5/16	3x2x⅜	3x3x 5/16	¼x20½	.....	32.09	15 26	15.49	317.92	313.2	8566c 8694t	9346	5671	23583	6 01 above	0.049

Lake Shore & Michigan Southern Railway with a dynamometer car having nominal capacity in apparatus of 300,000 lb. It was found that the tensile and buffing strains, with an engine having a tractive power of 36,000 lb., were from 50,000 to 70,000 lb. and 80,000 to 150,000 lb. respectively, depending upon the skill of the engineer in manipulating the engine, the train remaining intact. In coupling an engine to its train, buffing strains from 65,000 to 142,000 lb. were obtained. Thirty cars moving at about 6½ miles per hour, and coupling on to ten loaded cars with brakes set, gave a shock of 376,492 lb. It would therefore appear from the above results, that provisions should be made in designing a steel underframe box car to take care of an impact blow of 350,000 lb. transmitted throughout all sills.

It would therefore seem advisable to assume an end strain of 200,000 lb. on the center sills of box cars with steel side frames and 300,000 lb. for box cars with wood side frames for the reasons previously mentioned. If the center line of coupler were directly on line with the neutral axis of the section to be analyzed, the stress per square inch on the center sills due to end shocks would be equal to the buffing force B divided by the area A of section. Referring to the data compiled in Tables 11 to 14 on center sills, the area of the sills is given both at the center line of the car and near the bolster. The eccentricity e or the distance from the center line of the draw gear to the neutral axis is also given for these sections. Stress at the bolster due to eccentricity equals $\frac{B_e}{S_t}$ when the center line of the draw gear is below the neutral axis, and $\frac{B_e}{S_c}$ when the center line is above the neutral axis. The combined stress at the bolster equals $\frac{B}{A}+\frac{B_e}{S_t}$ or $\frac{B}{A}+\frac{B_e}{S_c}$, depending upon the location of the center line of the draw gear. At the center line of the car, compression stress due to the lading equals $\frac{M}{S_c}$. Stress due to eccentricity equals $\frac{B_e}{S_c}$. Stress due to end shock equals $\frac{B}{A}$. When the center line of the draw gear at the center of the car is below the neutral axis, the combined stress equals $\frac{M}{S_c}+\frac{B}{A}-\frac{B_e}{S_c}$, and if the center line is

TABLE 12 CARS WITH STEEL SIDE FRAMES AT CENTER

Road	Sill Type	Section Type	Depth over Flanges, In	Web Plate, In.	Outside Top Angle, In.	Bottom Angle, In.		Cover Plate, In.		Min Area, In. S_t In	Neutral Axes		Section Moduli		Max. Stress due to Vertical Loads Lb. per Sq. In.	Compression due to End Stock, Lb. per Sq In.	Compression due to Eccentricity, Lb. per Sq In	Maximum Combined Compression Lb per Sq In	Center Line of Draw Gear above or below Neutral Axis, In.	$\frac{1}{A}+\frac{e}{S}$
						Outside	Inside	Top	Bottom		X_c	X_t	c	S_t						
C. & O.	G	C	15		.	.		5/16x19¾	..	25.96	6.00	9.31	150.03	96.69	10972 c 17025 t	7704	7345	11331	5 56 below	0.095
Erie. .	H	D	15			..	.. ..	. .	..	18 73	7 092	7 908	80 0	71.72	20311c 22655 t	10678	10275	20714	4 158 below	0.1312
Can. Pac	H	D	15		..	.. ..	.....	.....	.....	18.73	7.092	7.908	80.6	71.72	20311 c 22655 t	10678	13270	17719	5 408 below	0.1287
Wabash.	I	C	15			.	..	5/16x20	.....	26 05	5 98	9 33	151 04	96.8	10887 c 16987 t	7677	6806	11758	5 11 below	0.091
Frisco	J	E	26	¼	3x3x¼	3x3x ⅜	3x3x 5/16	¼x20	..	26 89	12.38	13 87	235 53	210 23	8725 c 9775 t	7437	717	16909	88 above	0.04
U. P.	K	G	27¾	¼	3⅞ ff'ge	3½x3x¾	3½x3x⅜	¼x23	....	28 78	13 94	14 06	261 67	259 43	9053 c 9131 t	6949	3829	19831	5 0 above	0 053
P. R R	L	H	20	¾	4 ff'ge	4 ff'ge	4x4x 5/16	⅜x24	...	35 91	9.55	10 82	258 66	228 30	10600 c 12013 t	5569	2265	18434	2 93 above	0.038

TABLE 13 CARS WITH WOOD SIDE FRAMES AT BOLSTER

Road	Sill Type	Section Type	Depth over Flanges, In	Web Plate, In	Outside Top Angle, In.	Bottom Angle, In		Cover Plate, In		Min Area, Sq In	Neutral Axes		Section Modulii		Compression due to End Shock, Lb per Sq. In.	Compression due to Eccentricity, Lb. per Sq. In.	Maximum Combined Compression Lb. per Sq. In.	Center Line of Draw Gear above or below Neutral Axis	$1 + \frac{e}{A}S$
						Outside	Inside	Top	Bottom		X_c	X_t	S_c	S_t					
D. L. & W.	A	B	12					$\frac{1}{4}$x19	$\frac{1}{4}$x19	24.20	6.25	6.25	163.11	103.11	12396	8728	21124	3.00 below	0.07
C. R. R. of N. J.	A	C	15					$\frac{1}{4}$x20$\frac{1}{2}$		23.91	6.33	8.62	134.27	95.28	12547	2109	14656	0.67 below	0.048
N. Y. O. & W.	B	G	15	$\frac{1}{4}$	3$\frac{7}{8}$ fl'ge	3$\frac{1}{2}$x3x$\frac{7}{16}$	3$\frac{1}{2}$x3x$\frac{7}{16}$	$\frac{1}{4}$x21$\frac{1}{4}$		25.60	8.42	6.83	119.84	147.70	12000	5238	17238	2.58 below	0.057
P. & R.	C	E	11$\frac{1}{4}$	$\frac{3}{8}$	4x4x$\frac{1}{2}$	4x4x$\frac{1}{2}$	4x4x$\frac{1}{2}$	$\frac{1}{4}$x22$\frac{1}{2}$		36.18	5.91	5.59	123.53	130.60	8291	1929	10220	0.84 below	0.033
B. & A.	D	E	12$\frac{7}{8}$	$\frac{1}{4}$	3x3x$\frac{3}{8}$	3x3x$\frac{3}{8}$	3x3x$\frac{3}{8}$	$\frac{1}{4}$x20$\frac{1}{4}$		23.90	6.28	6.84	110.31	101.13	12552	4331	16883	1.46 below	0.055
C. & N. W.	E	C	15					$\frac{3}{8}$x20		27.30	5.76	9.61	164.24	98.44	16989	18986	29975	6.23 below	0.099
Un. Pac.	F	F	12$\frac{7}{8}$	$\frac{1}{4}$	3x3x$\frac{5}{16}$	3x3x$\frac{3}{8}$		$\frac{1}{4}$x20$\frac{1}{2}$		19.68	5.11	8.01	97.61	62.33	15719	19901	35620	4.135 below	0.118

above, the combined stress equals $\frac{M}{S_c} + \frac{B}{A} + \frac{B_v}{S_c}$. The ratio of stress to end strain is obtained by the formula $\frac{1}{A} + \frac{e}{S}$, in which S represents the section modulus, S_t to be used if the center line of the draw gear is below, and S_c if above, the neutral axis. The Car Construction Committee of the Master Car Builders' Association recommend that the above ratio on new cars should not exceed 0.06. They also recommend a minimum area of 24 sq. in. of center sills.

Tables 11 and 12 give the maximum stress on center sills due to vertical loading which was obtained by assuming a uniform load distributed throughout the sill. Calculations are based on the weight of car body, A, the lading, B, and the oscillation, C. The car body, weight A, carried on center sills was taken at 20,000 lb. except for Philadelphia & Reading box car, in which the weight used was 24,000 lb. (assuming as two-thirds total weight of car body and underframe). The lading B for 60,000 lb. capacity cars was assumed as 66,000 lb., for 80,000 lb. capacity cars was assumed as 88,000 lb. and for 100,000 lb. capacity cars was assumed as 110,000 lb. The oscillation C was taken at 20 per cent of the total sum of lading and weight of car body carried.

The calculations for center sill load for box cars with wood side frames were made as follows: load per square inch of floor space

$$w = \frac{A + B + C}{lm}$$

Total uniform load on center sills

$$W = wl\,(x + y)$$

where

l = length over centers of end posts, in inches
m = distance over centers of side posts, in inches
x = spacing of center sills
y = distance from back of center sill to center of side post, in inches (see Figs. 29 and 30).

The calculations for center sill load for box cars with steel side frames were made as follows: load per square inch of floor space

$$w_1 = \frac{\frac{A}{3} + B + C}{lm}$$

Total uniform load on center sills

$$W = w_1 l\,(x + y)$$

Bending moment of center sills

$$M = \frac{W}{2}\left(\frac{l}{4} - c\right)$$

where

M = maximum bending moment at center of car

TABLE 14 CARS WITH STEEL SIDE FRAMES AT BOLSTER

Road	Sill Type	Section Type	Depth over Flanges, In.	Web Plate, In.	Outside Top Angle, In.	Bottom Angle, In.		Cover Plate, In.		Min Area, Sq In	Neutral Axes		Section Modulii		Compression due to End Shock, Lb per Sq. In	Compression due to Eccentricity, Lb. per Sq. In	Maximum Combined Compression Lb. per Sq. In.	Center Line of Draw Gear above or below Neutral Axis, In.	$1 + \frac{e}{A}S$
						Outside	Inside	Top	Bottom		X_c	X_t	S_c	S_t					
C. & O.	G	C	15	.	. . . . .			$\frac{3}{16}$x19$\frac{3}{4}$	.	25.96	6.00	9.31	150.03	96.69	7704	11500	19204	5.56 below	0.095
Erie. . . .	H	D	15	.	. . .					19.8	7.5	7.5	83.4	83.4	10101	8993	19094	3.75 below	0.095
Can Pac.	H	D	15	. . .	. . . . .	. .		.	. . .	19.8	7.5	7.5	83.4	83.4	10101	11990	22091	5.0 below	0.110
Wabash	I	C	15	. .	. . . . .			$\frac{3}{16}$x20		26.05	5.98	9.33	151.04	96.8	7677	10620	18297	5.14 below	0.091
Frisco. . .	J	E	13$\frac{7}{8}$	$\frac{1}{4}$	3x3x$\frac{1}{4}$	3x3x$\frac{3}{8}$	3x3x$\frac{3}{8}$	$\frac{1}{4}$x20	. .	22.34	6.93	7.19	108.01	104.1	8953	8760	17713	4.56 below	0.088
Un. Pac.	K	G	13	$\frac{1}{4}$	3$\frac{7}{8}$ fl.	3$\frac{1}{2}$x3x$\frac{3}{8}$	3$\frac{1}{2}$x3x$\frac{3}{8}$	$\frac{1}{4}$x23	.	23.03	6.86	6.39	103.54	111.16	8684	4174	12858	2.32 below	0.063
P. R. R.	L	H	11	$\frac{3}{8}$	4 fl.	4 fl.	4x4x$\frac{5}{16}$	$\frac{3}{8}$x24	.	30.68	5.38	5.99	125.62	112.83	6517	2198	8715	1.24 below	0.043

c = distance from center line of bolster to center of end post, in inches

$\frac{M}{S_c}$ = compression per square inch

$\frac{M}{S_t}$ = tension per square inch

Bending moment at any point x

$$M_x = \frac{W}{2}\left(x - c\right) - \frac{Px^2}{2}$$

where

x = distance in inches from center of end post to any section between bolster and center of car

P = load per lineal inch of sill

In calculating the Pennsylvania Railroad box car, it was assumed that the cross bearers transmitted to the center sills a certain proportion of weight of the car

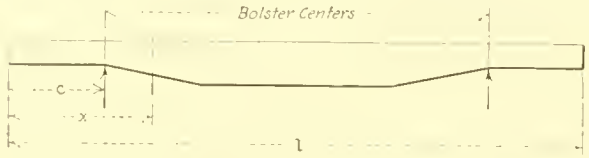


Fig. 29 Diagram for Determining Bending Moments

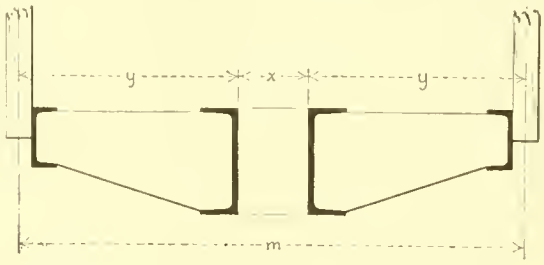


Fig. 30 Diagram for Load Distribution

body, thus producing an additional bending moment in the center sills.

From Tables 11 to 14 are obtained the data presented in Table 15. For the 36 ft. cars with wood body framing, it would appear that the averages shown for the area and stress both at the bolster and the center of the car approach figures which are safe for general practice. For the 36 ft. cars with steel body framing, the average stress per square inch behind bolster is too high for safe practice and should be reduced by increasing the area. The low combined stress at center of car is due to the center line of coupler being located about 5 inches below neutral axis, which reduces the compression due to direct end shock. At the center of car the stress due to lading alone is also too high for safe operation. For the 40 ft. cars with wood body framing, the average stress per square inch is entirely too high and should be reduced by increasing the area of the section and cutting down the eccentric load due to end shock; this also applies to the section at the center of the car. In the 40 ft. cars with steel body framing, the maximum combined stress at the center of the car is a trifle high.

Table 15 Data Compiled on Areas and Stresses in Center Sills

Area of Center Sills

	At Center			At Bolster		
	Min.	Max.	Aver.	Min.	Max.	Aver.
36-ft. cars, wood frame. ...	26.84	45.01	33.37	23.90	36.18	26.64
36-ft. cars, steel frame.. ..	18.73	26.05	22.19	19.80	26.05	22.72
40-ft. cars, wood frame....	32.09	33.125	32.60	19.08	27.30	23.19
40-ft. cars, steel frame.	26.89	35.91	30.52	22.34	30.68	25.35

Maximum Combined Stress

	At Center			At Bolster		
	Min.	Max.	Aver.	Min.	Max.	Aver.
36-ft. cars, wood frame....	12505	23514	18274	10202	21124	16020
36-ft. cars, steel frame.....	10539	20714	15182	18297	23069	20409
40-ft. cars, wood frame.....	15607	23583	19595	29975	35620	32798
40-ft cars, steel frame.....	16909	19831	18393	8707	17713	13093

In all of these cases it is well to note that the relation of the center line of the coupler to the neutral axis has an important bearing on the strength of the sills. At the center of a car with fish-belly type sills

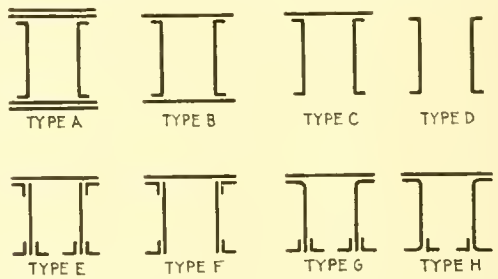


Fig. 31 Typical Sections of Center Sills showing Lack of Standardization

the center line of the coupler is usually above the neutral axis, which adds to the total combined compression; whereas, with rolled steel sills, the coupler center line being below the neutral axis, will counteract somewhat the compression due to impact blow. This leads me to believe that nothing is gained by making the depth of fish-belly sills at the center any greater than is required to take care of the vertical loads. It will also appear that a fish-belly type sill is necessary for all types of cars mentioned of 80,000 and 100,000 lb. capacity, except 36 ft. steel side frame cars, which will render good service when using a center sill construction of plates and channels.

Table 10. This table shows the general practice in designing body bolsters, cross bearers, side sills, and draft sills. For body bolsters, it is general practice to use two pressed steel channels spaced at various distances apart with cover plates top and bottom. The best designs have a spacing 6 in. to 8 in. between webs. For cross bearers, a variety of designs exist, the later

types consisting of heavy I-beams passing directly through the center sill web plate and extending the width of the car between side sills. This plan is also followed out on the intermediate floor beams and makes a neat and substantial arrangement. The general practice is to use a pressed steel channel with top and bottom cover plate.

For draft sills, the practice is, where structural steel channels are used for center sills, to extend the same channel to the end sill to serve as draft sills. It has been customary when fish-belly type center sills are used, to provide a pressed steel Z-shape draft sill and splice to center sill web plate projecting through the bolster. There is a tendency on the part of designers today to do away with the splice by extending the web plates of center sills and providing outside angles to form the draft sill, using a continuous cover plate. Where pressed steel center sills and cover plates are used, the practice has been followed of extending this construction to the end sill, extending the cover plate too near the end of the sill. This construction requires the use of web plates about 5/16 in. thick, so as to provide sufficient bearing area for draft lug rivets. I believe when draft sills have sufficient net area behind the bolster stop, that considerations of economical construction would warrant dispensing with the splice, as in view of the additional cost of a splice on 1000 cars, the expense of its application is not warranted when considering the number of sill failures likely to occur due to its omission.

As to draft gears, data regarding the type used have not been tabulated. It is sufficient to say that of the cars enumerated, six were equipped with spring draft gears and nine with friction gears. The impact blow resulting from cars coming together is practically absorbed by the draft gear. Friction gears are more efficient in this respect, absorbing a much greater percentage of total energy as compared with spring gears. This subject was thoroughly discussed by the members of the Master Car Builders' Association some years ago, a full account of which appears in their proceedings. Owing to the large variety of gears in service, necessitating numerous designs of draft lugs, key attachments, etc., it would appear that, if a standard arrangement of draft gear and all appliances connected therewith were adopted by all railroads, it would result in great economy of maintenance. This should include striking plates and carry irons, which on a large number of cars are not of sufficient strength due to arrangement of end sills.

The stresses in steel body framing can be obtained by graphical as well as analytical methods. Fig. 32 indicates the manner in which the stress diagram for vertical loads is obtained, a uniform load of 70 lb. to the lineal inch having been considered, corresponding to a uniform load of approximately 30,000 lb. for a 36 ft. car. The light lines indicate tension and the heavy lines, compression. The side sill and top plate at the door opening are subjected to the same stress, but it is the usual practice to provide more area in the side sill to take care of unsymmetrical loading. The posts and braces must also resist crossbending stresses due to pressure of lading. The bending moment due to this cause is

$$M = \frac{H^3 \tan^2 \theta D W}{18 \times 1728}$$

H = height of load in inches
D = one-half distance between posts in inches
W = weight of lading in pounds per cubic foot
$\theta = 1\frac{1}{2}$ (90 deg.—angle of repose).

By examining the tables shown giving the comparative data of various items which enter into the con-

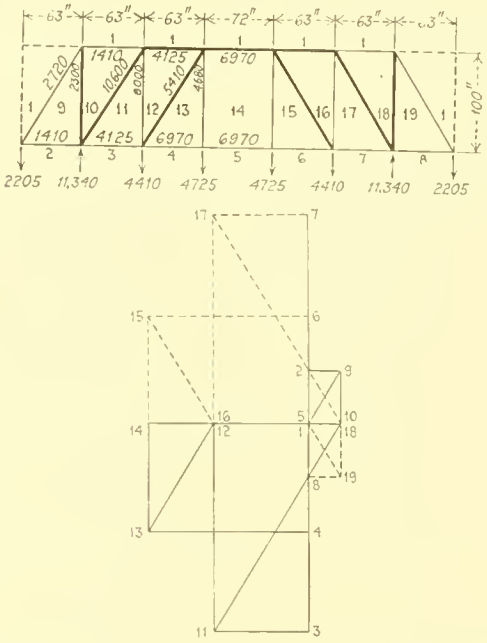


Fig. 32 Graphical Method of Determining Stresses in the Members of Steel Side Frames

struction of a box car, it is surprising that more has not been done in the way of standard construction. The large expenses which railroads are now compelled to face due to repairs of freight cars could be partially reduced if standard designs were in use throughout the country. Repairs would be facilitated due to the use of standard materials throughout for various types of cars, fewer cars would be held up at car repair shops awaiting material from foreign roads, and interchange of cars would not be a hardship to any railroad, as all cars would be of equal strength. Also drawing room expenses would be reduced both for the railroad and car builder, and repair parts could be produced by cheaper methods than as followed out at present, due to elimination of a variety of designs and shapes, principally castings and pressed steel parts.

STEEL UPPER FRAME BOX CARS

By R. W. Burnett,[1] Montreal

Non-Member

The paper which is confined solely to superstructure details of the steel frame box car is intended to apply in general to steel frame practice as developed in connection therewith. While the early development of steel upper framing is passed over rather briefly, many of the important considerations that have influenced its adoption are discussed in detail, particularly as viewed by the Canadian Pacific Railway. The information and data presented are based on the writer's experience in this railway system in connection with the design, construction and maintenance of 30,000 cars of this type, which represent an investment of $30,000,000.

Credit is due to Mr. C. A. Seley, mechanical engineer of the Rock Island Lines, for designing the first outside sheathed steel superstructure box cars that were constructed in large numbers. The introduction of steel into the superstructure of the box car, and the development of the outside sheathed steel superstructure in particular, were discussed so thoroughly by Mr. Seley in his comprehensive paper[2] before the Franklin Institute in January 1910, that I have thought it unnecessary to go over this same ground, but will review only briefly the development of the box car from the all-wood car through the intermediate stages of steel underframe cars.

The original wooden car, with the single spring draft rigging having the check castings bolted to the sills, gave little if any more trouble than modern equipment, due principally to the shorter trains, lesser density of traffic and to the use of link and pin couplers which compelled gentler handling of trains than is prevalent today. The steel underframe car was built mainly to secure a stronger center construction for the attachment of draft rigging and to get away from the trouble caused by wooden sills breaking and splitting, broken draft bolts, etc.

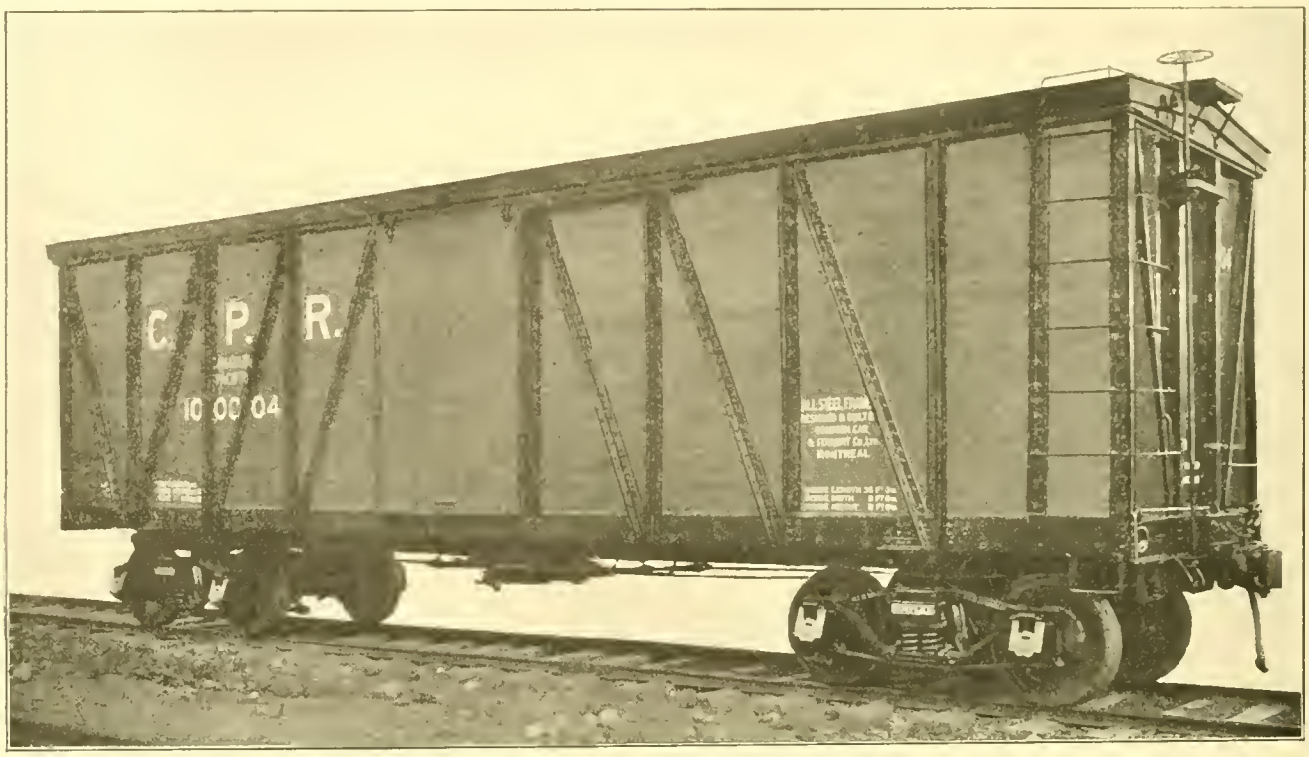


Fig. 1 First Inside Sheathed Steel Frame Car built by the Canadian Pacific Railway

While having many advantages over the old wooden car, the steel underframe car developed some troubles peculiar to itself, the most important being due to the fact that the body being carried on a rigid frame and not held together by the strains resulting from its weight, as in the old trussed cars, has a tendency to develop slack in the superstructure. This in turn affects the roof and sheathing. One principal trouble with outside sheathed cars is that, after they have been in service a comparatively short time, the sheathing frequently loosens at the end sill and at the side sills near the bolsters with resultant leakage of grain.

There were some steel frame box cars built previous to 1909, but the writer has been able to secure data on only the outside sheathed types. Of these 2700

[1] General Master Car Builder, Canadian Pacific Railway Company

[2] Vol. 169, No. 4, April, 1910, p. 278

Presented at the Annual Meeting, December 1913, of The American Society of Mechanical Engineers

were in service on the Norfolk & Western, of which the first 100 were built in 1902; the owners advise they were satisfactory and the same type has been purchased on subsequent orders. The Rock Island and Frisco lines had in service at that date approximately 5000 cars similar to the Norfolk & Western, and these also appear to have given satisfaction as the owners have reordered the same type several times. All of these, however, were outside sheathed and as regards leakage at the sills, had comparatively little advantage over the wooden cars. Recently both of these lines have purchased some inside sheathed cars. The Frisco car of this type is fully described in The Railway Age Gazette, October 3, 1913.

In 1908 the Canadian Pacific Railway designed the steel frame inside sheathed box car as shown in Fig. 1. This car avoided the disadvantage of the outside sheathed car which had not been accomplished by the steel frame cars constructed up to that time, and at once obtained a further reduction in weight and provided for cheapness of maintenance by the use of steel superstructure, without the additional lumber required by the outside sheathed car. With practically no preliminary experimenting 500 of these cars were built and since over 30,000 have been built similar to the first cars, with the exception of several refinements of details, such as corner and door posts, end doors and side plates, and joining of flooring and lining. These changes have not affected the general design of the car, but are improvements that have been introduced from time to time to reduce weight and simplify the construction. The latest type of car is shown in Figs. 3 to 5.

The steel frame outside sheathed car has several advantages over the types previously used, notably in that the tare ton weight is low in proportion to the capacity. There is such a variation in the figures used for the cost of hauling per ton-mile, that no attempt is made to say what the saving would amount to, but certainly the advantage of having a car equal, if not superior to other cars in all respects, weighing from 1000 to 5000 lb. less will appeal to all traffic and operating men. Not only is there that much less dead weight to haul when the car is empty or partly loaded but additional lading can frequently be carried. The actual limit on the paying load that can be carried in a properly designed car is the total weight on the axles. Thus, a car having 5 in. by 9 in. axles with such a tare weight that, when deducted from the capacity of the axles, allows the car to be safely loaded to 88,000 lb. could, if dead weight be reduced by 3000 lb., safely carry a paying load of 91,000 lb. and retain the same strength. Thus the actual capacity of the car is increased almost 4 per cent with a better ratio of paying to dead load.

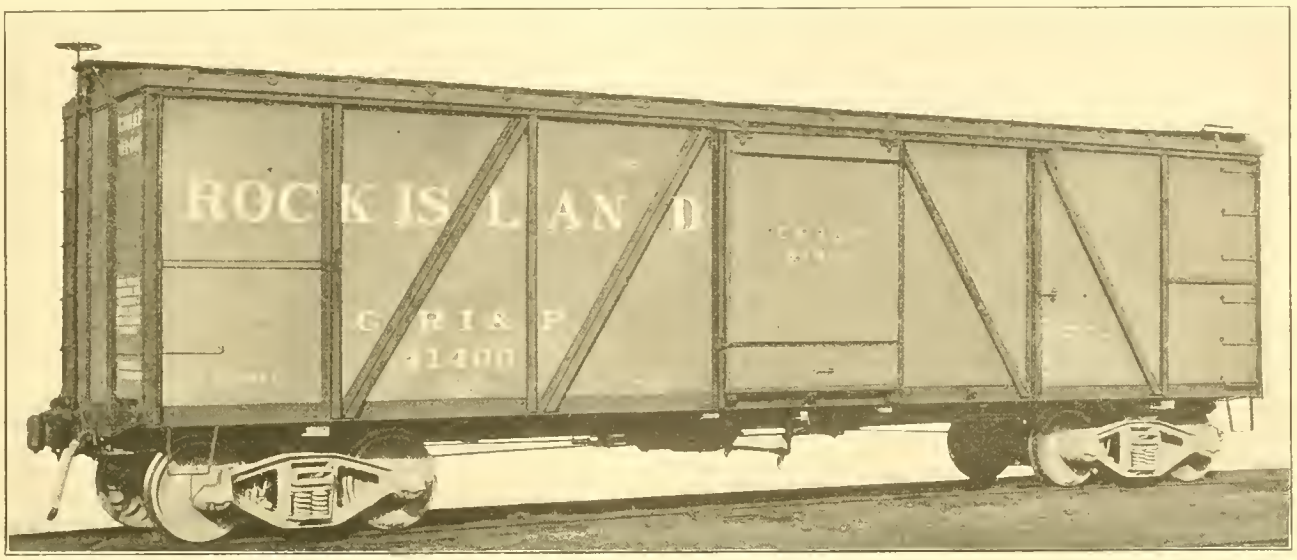


Fig. 2 Type of Inside Sheathed Steel Frame Car used by the Rock Island System (40 Ft., 40 Ton)

With the wooden superstructure, it had been thought necessary to assist the superstructure by heavy roof construction, some going so far as to use different methods of diagonal bracing, but with the steel car it has been found that there is no appreciable local movement of the framing in the heaviest service which makes a simple proposition of the roof as it has only to take care of itself. This presents a simpler problem to roof designers, making it possible to design a roof much lighter, without necessity for use of purlins or ridge poles to strengthen the car. It is obvious that unnecessary weight in the roof raises the center of gravity, and increases the tare weight and cost and has other disadvantages.

In explanation of the local movement of this style of framing, it is well to mention tests we have made in jacking up this car, which demonstrated that the car would take a gentle twist from end to end, allowing the bolsters to be slightly out of the same plane hori-

zontally. This twisting was accomplished without any perceptible local distortion of the sides or ends. The capacity for twisting is a condition to be desired as it allows a car to adjust itself to uneven track conditions.

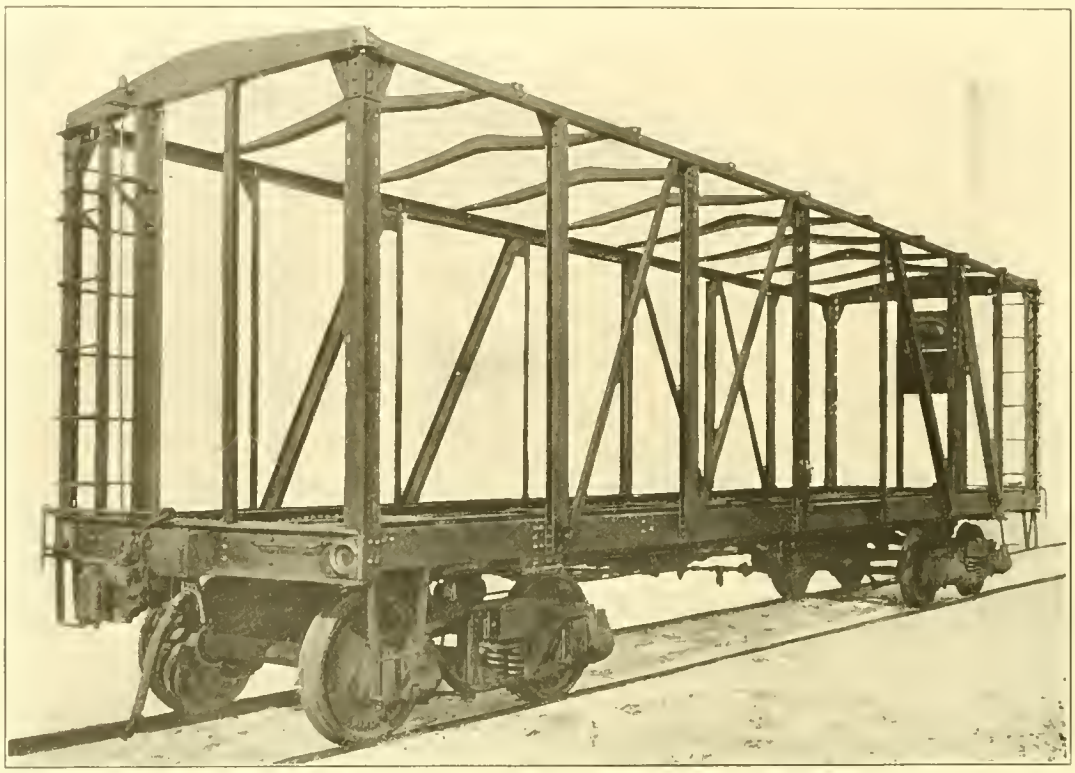


Fig. 3 Steel Frame of Canadian Pacific Railway Box Car Ready for Lining

In addition to being 5½ in. narrower than the outside of the sheathing of a wooden car, the superstructure of the Canadian Pacific Railway car is protected by the framing, so that a side swipe that would do serious damage to an outside sheathed car frequently does not touch the lining and is resisted by the framing without damage to the posts or braces. Frequently it is found that a side swipe that would almost demolish the sides of a wooden car only bends the steel framing, and in making repairs, the lining is merely removed, posts and braces straightened and the original lining replaced, the whole cost being the comparatively small labor charge. Jacking frames are being installed at all of our principal repair points for all classes of steel cars, and while not original with the Canadian Pacific Railway, have been amplified better to take care of steel frame box cars. With these frames, many jobs that would require the car to be cut apart, taking several days, can be done in a few hours without cutting rivets. With modern steel frame cars, these jacking frames are as much a necessity as the blacksmith shop or any other part of the shop.

With the outside sheathed car, it is difficult to clean a car properly when it is unloaded, on account of grain lodging between the framework and also on account of the opening where the posts and braces meet at the bottom becoming obstructed, resulting in grain being retained between the sheathing and lining with resultant complaints from shippers. All of this is overcome by the clean joining of the lining and the floor in the

Fig. 4 End View of Canadian Pacific Inside Sheathed Car showing Grain-Tight End Doors

steel frame cars, and it is believed a change of this kind would have come years sooner if designers had kept in close touch with service conditions. One advantage of the steel frame car is that outside of possible repairs due to wreck damage and to wear and tear of couplers, wheels, brake shoes and journal bearings, the car does not deteriorate more rapidly in service than when stored.

Fig. 5 View of one of the Latest Inside Sheathed Cars built by the Canadian Pacific Railway (36 Ft., 40 Ton)

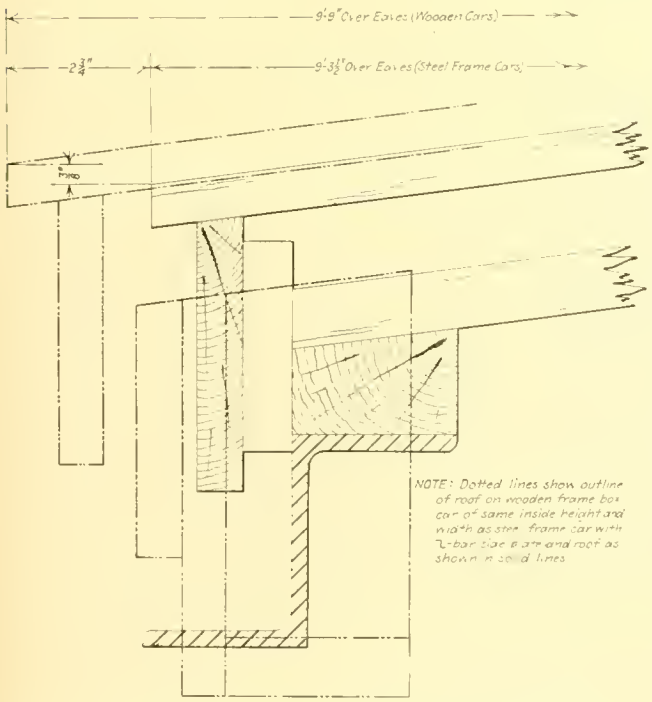


Fig. 6 Detail of Roof Clearances on Steel Frame and Wooden Box Cars

The grading of lumber for use in these cars is an item that has received much consideration. Yellow pine or fir has so far been the principal lumber used, although we have experimented to some extent with spruce. Spruce has the advantage of being lighter, but it seems to be more difficult to dry it sufficiently for this purpose. Great pains have been taken to avoid knots that are too large or numerous and while it is generally desirable to have lumber as free from knots as possible, I have never in the inspection of many hundreds of cars, seen where a knot had fallen out. It is, however, desirable to have lumber as free from sap and shakes as possible and thoroughly dry.

When the first of these cars were built outside of the Canadian Pacific Railway shops we had considerable difficulty in getting the lumber properly dried due to lack of both experience and facilities on the part of the car companies. We have about 3000 cars on which the lumber has shrunk and given them a bad appearance, but this result was expected, as when the cars were built the lumber was quite green. The sheathing of these cars could be tightened for less than $4 per car, but very few have been tightened owing to receipt of practically no reports of loss or damage to lading due to the shrinkage; also as they do not fre-

REPORT OF MOISTURE IN LUMBER FOR LINING BOX CARS

Built by ..... At .....

C. P. R. Equip. Order No.... For.. .....Number of Cars .....

Report No.....

Moisture determination strictly in accordance with C. P. R. Spec. No. 213 C.

Samples obtained every other day during construction, with a minimum of one sample for each one hundred cars built. Result of each test must be promptly recorded on this sheet and sent to R. W. BURNETT, Gen'l M. C. B., Montreal.

Lab. No.	Date of Sample	Cars Completed	Car Nos. Represented	Moisture Per Cent	Average To Date	Orig. Width Inches	Shrinkage Inches	Average To Date Inches	REMARKS

Signed Engineer of Tests.

FIG. 7 FORM USED FOR REPORTS TO CANADIAN PACIFIC RAILWAY ON MOISTURE DETERMINATIONS ON LUMBER

quently reach our main repair tracks, being shopped only for such repairs as wheels, or wreck damage, we have not considered it advisable to shop the cars for a defect which is almost entirely a matter of appearance. The lining shrinks as much in two months of summer weather, as it ever will.

The lining should not be matched before drying, as it warps and curls rendering it difficult to make a tight joint. The rough size of lumber should be at least 1/4 in. greater than finished dimensions. In establishing limits for drying lumber no information or data could be secured whatever, and after experimenting we came to the conclusion that a piece of this lining of full cross-section subjected to a temperature averaging 170 deg. fahr. for 96 hours should not lose more than 6 per cent in weight and that lumber represented by samples losing more than 10 per cent must not be used until further dried.

The variable condition of the lumber when taken from the yard makes it necessary to use careful judgment as to the length of time it should be kept in the kiln. At the Angus shops of the Canadian Pacific Railway this responsibility falls on the wood-mill foreman whose constant attention to this feature makes him the best fitted for the purpose. The average moisture loss reported by the test department for lumber used on cars now building at the Angus shops is 5.25 per cent which shows that we are getting very satisfactory results from the kilns. A number of tests were made last year on lumber taken from the yard. These tests showed a moisture loss of between 25 and 30 per cent which shows the importance of drying

FIG. 8 VIEW OF STANDARD CANADIAN PACIFIC STEEL FRAME CAR FITTED WITH CORRUGATED STEEL LINING

lumber properly. The form shown in Fig. 7 is used for reporting results of tests both at Angus and outside shops.

Due largely to our insistence, nearly all the car plants in the country are now equipped with dry kilns, and any possible additional cost of drying lumber in excess of what has been considered good practice in the past would be less than $1 per car. Such drying would make the car side practically the same as one board so that it is absurd that the possible shrinkage of lumber should be considered as any reason for this type of car not being built. It has been claimed that lumber can be so dried that it will swell and bulge, but we have never found this to occur. We have had

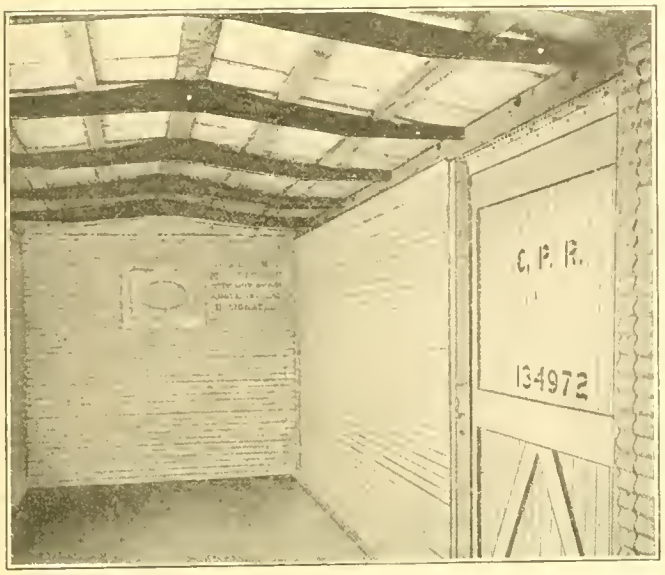


Fig. 9 Interior of Canadian Pacific Steel Frame Car with Corrugated Steel Lining

cases where lumber slightly moist has dried more rapidly on the inside, due to that side not being painted, and made the outside of the boards slightly convex, with tight joints that could be easily mistaken for swelling, whereas the opposite is the case. We have kept a car with very green lumber in the passenger shop with a high temperature for over a month until the lumber was absolutely bone dry, and then put it outside with doors open through four weeks of constant raining spring weather, with the result that there was no closing of the cracks that could be detected which further proves that there is nothing to be feared from lumber being too dry.

The defects in the sheathing that must be most closely watched are shakes or splits that extend obliquely downward into the car which must be knifed in with paste before the car is painted. The edges of the lining should be painted, and we have found this can be done more easily and thoroughly by dipping the boards and putting them through between two rubber scrapers which removes the surplus paint leaving the edge thoroughly coated. This gives a thin coat of paint on the inside of the car which is an advantage in causing the lumber to dry more uniformly and diminishes the tendency to warp. Narrow boards have the advantage of having less tendency to warp, and also if the lumber should not be thoroughly dry, there is less total shrinkage for each board making the space between the edges narrower. The steel work and roofing are painted the same as other cars. This considerable space has been given to the grading and drying, and painting of lumber, as we have found that these factors have required much more attention than everything else combined in connection with the car.

The development of the inside sheathed car has been so rapid and the experience with it so uniformly satisfactory, that I feel safe in saying that its introduction in such large numbers on so many roads in so short

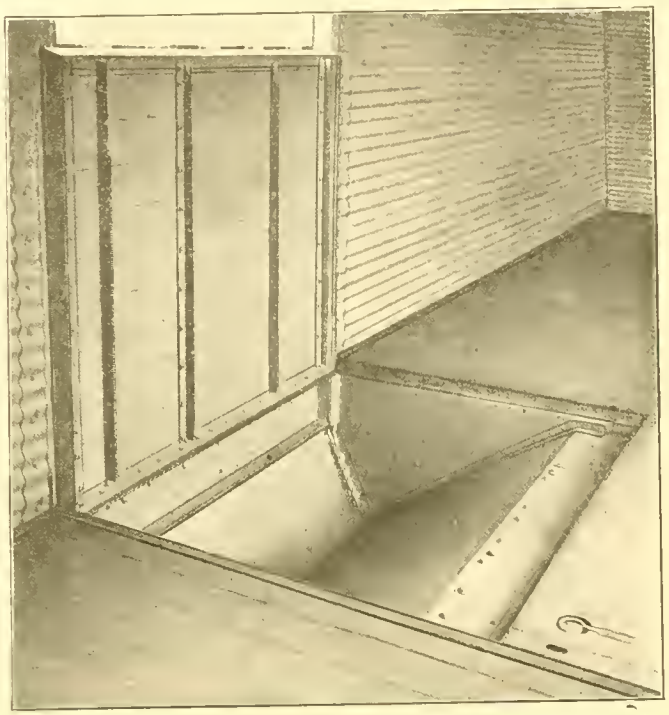


Fig. 10 Detail View of Hopper Opening in Floor of Corrugated Steel Lined Car

a time indicates more nearly a tendency toward the adoption of a standard car than has any distinct type of car outside of patented cars for special service. It is certain that there will be no backward movement to a wooden superstructure and that this car with possible modifications will remain a standard car unless some superior type of car is developed. It may be stated as the writer's opinion that no committee will ever develop a car that will be adopted as standard but that the nearest we will ever get to a standard is what may be developed by one or two persons given a free hand, and the merit of which is so pronounced that it forces itself upon the country.

With the use of structural steel there is less necessity of carrying special parts in stock on account of

repairs being largely a question of labor, and it seems that with this type of car the necessity from a repair standpoint for a standard car is decreasing. This is further borne out by the fact that for the 30,000 cars of this type we have ordered no material for repairs and carry none in stock outside of material common to all cars, except lining; of the lining, our stock amounts to practically nothing. We save out sufficient of the parts from cars destroyed to make up our stock of repair parts, but have found it necessary to use very little of this. There are, of course, many valid reasons why cars should be made to standard inside dimensions and outside clearances.

To look at the matter in another way, the wheels, axles, journal bearings, journal boxes, couplers, brakes, safety appliances, etc., which constitute the removable and perishable parts, are all standard and when it is remembered that nearly all of the remaining parts of the cars are standard rolled shapes which are easily obtained either from the mill or from stock in all principal cities, it is apparent that we now have in effect, a standard car, or at least a car of standard parts. A car of different dimensions would not increase the cost of maintenance as long as standard shapes are used; nor would it if every lot of cars is designed differently, as long as proper strength is maintained, and any change in design would usually be to increase the strength. In other words, to keep a car as close as possible to standard and reduce cost of maintenance, rolled shapes should be used in preference to pressed shapes where possible.

It is my belief that the people who are urging the adoption of a standard car for maintenance reasons have in mind the remaining wooden cars for the maintenance of which large quantities of timbers and castings have to be kept in stock. It is of vital importance that the parts be standardized if that style of construction is to be continued. It should not be overlooked that in a car constructed with rolled shapes, these parts seldom need renewal even when the car is wrecked, as they can easily be straightened or formed to the original shape at any car repair point, while wood would have to be replaced and pressed shapes would call for special dies to reform them. With a wooden box car the amount of material necessary to carry in stock and use for repairs increases rapidly with the age of the car. With a steel frame box car the amount of material necessary to carry in stock and use for repairs outside of parts common to all cars does not increase with the life of the car.

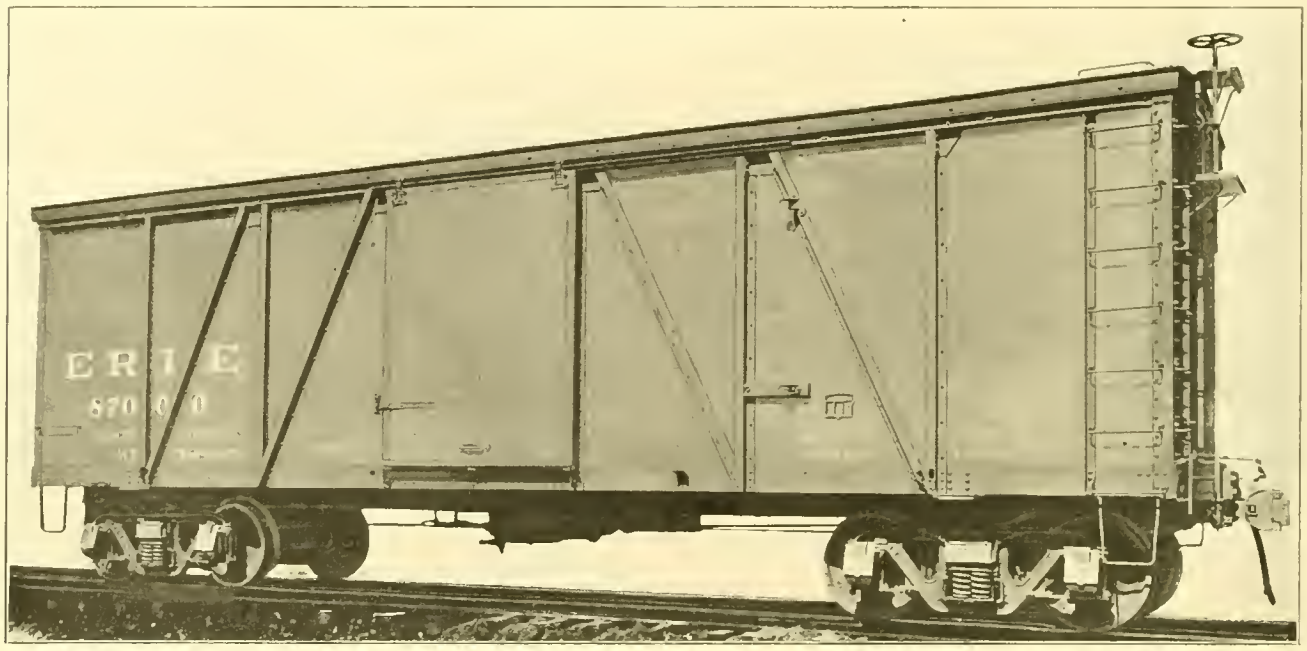


Fig. 11 View of Steel Frame Inside Sheathed Box Car in Use on the Erie Railroad (36 Ft., 40 Ton)

The wind resistance on the steel frame box cars with inside sheathing is slightly greater than on a smooth outside sheathed car, but on the other hand, it is less than on any ordinary type of stock car. The effect of wind resistance between box and stock cars, has never been great enough to require any distinction between them as to the number of cars that could be hauled in a train of either and is really a refinement that not even a dynamometer car can detect. A small change in the angle or velocity of the wind, or difference of the number of wheels running to one flange, or trucks somewhat out of square, affects the haulage of the train too much to enable any satisfactory figure for the difference in the wind resistance of the various types of car to be obtained. There is a certain stretch of track on the western plains of about 40 miles without a curve and practically level where high winds are frequent, on which the haulage capacity of locomotives

is dependent principally upon the wind, and yet even there it was found practically impossible to distinguish between the wind resistance of stock and box cars. From this, it is evident that the wind resistance of steel frame inside sheathed box cars as compared with outside sheathed cars may properly be ignored.

In the summer of 1911, we lined one of these steel frame cars with corrugated steel and found it to be as simple a matter as lining with wood, Figs. 8 and 9. We lapped and rivetted the sheets, which were No. 13 gauge, between the door and end, and had the corrugations on the side and end coincide, pressing into special corrugated angles in the corners to break the joints. At the floor, we straightened out about 4 in. of the corrugation and formed of it an angle that rests on the side sill, and on this the ends of the floor boards were superimposed, easily making as tight a joint as I have ever seen on any car. After 18 months of general service this car was brought in and on examination, found to be in as good shape as when constructed. It was interesting to note that, when inspected, the paint sealing the joints, where the side sheets lapped, was in no place seal broken, indicating that there is no material weaving or deflection of the sides. The paint was in perfect condition, there still being some gloss, indicating that in the use of steel there is no disadvantage as far as the painting is concerned. Different methods of lining with steel could be followed, and I am convinced that if experience proves that there is no damage to be feared from heat, cold or sweating, that steel lining will be largely used. But, I am also convinced that the use of steel lining with any insulation will never be extensively used as it adds to the cost and weight without affording any protection to the lading, which is not secured by the wood lining. An advantage of this construction is shown in Fig. 10, in the application of hoppers under the door openings, which were made without alterations to sills or cross bearers.

As regards the end of the car, Fig. 4, we use two 4 in. Z-bar end posts of 8.2 lb. per ft., with 1¾ in. lining which gives good service, but we intend to use on future cars two 5 in. end posts of 11.6 lb. per ft. with 2⅜ in. lining for a height of 4 ft. and 1¾ in. lining above that height. This, we feel, will protect any lading that needs protection. If a car gets such rough handling that wheels or rails, or similar lading would break through, it is better to have the boards broken than to distort the posts, as the lining can be replaced at any repair track with a minimum expense, while distorted posts would require sending the car to a steel car repair point. The single thickness end lining makes convenient the application of single thickness, grain-tight end doors.

Fig. 12 Steel Frame Box Car with Metal Roof in Use by the Grand Trunk System (36 ft., 40 Ton)

Out of 30,000 of these cars, 29 have been destroyed. Based on the length of time in service, this would average a loss of approximately one car per 1000 per year. Of the cars destroyed, 15 were burned, 14 were destroyed in wreck, 10 cars being destroyed on foreign lines. As the loss of cars by fire is in no way affected by the details of construction, I will eliminate them from the calculations. This then, based on the

length of time in service would give about one-half car per 1000 per year destroyed in wreck. As there is no appreciable deterioration of these cars in service, it is safe to assume that in the same service substantially the same rate of loss would continue, while with wooden cars the rate of loss would increase each year.

A conservative estimate shows that there are today approximately 65,000 steel superstructure cars, including outside sheathed, in service. Of this number 30,000 are Canadian Pacific Railway and nearly all the remainder belong to the roads whose names appear on the cars illustrated herewith. These I am able to show through the courtesy of the officers in charge of the mechanical departments of the several lines, whom I wish to thank for their willing assistance.

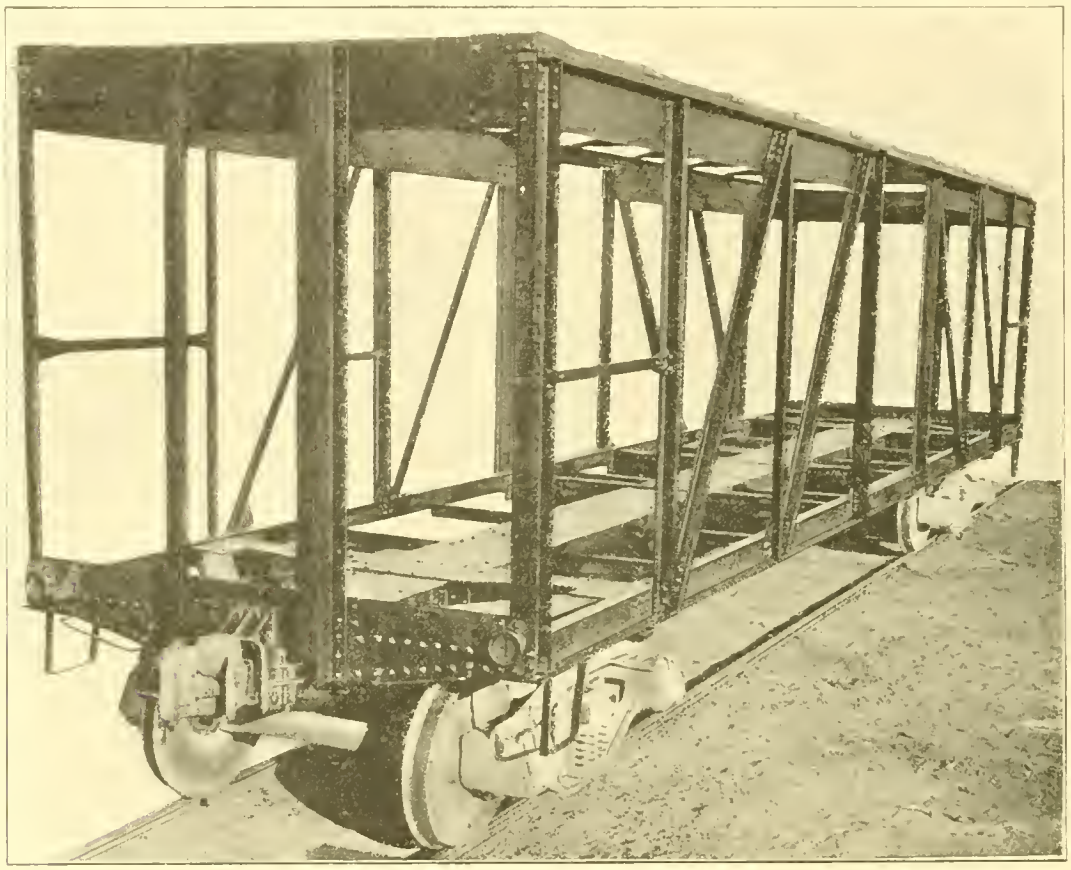


Fig. 13 View of Steel Frame of the Rock Island Car (Fig. 2) ready for Sheathing

DISCUSSION

H. H. Vaughan thought that Mr. Burnett's position was sound, that the structural steel car was to all intents and purposes a standard, as far as any car could be standard. He believed that one standard type or design of car would never be adopted. There were sure to be improvements and alterations that the different roads might think desirable; if standard material, easily obtainable, were used, and if certain parts, mentioned by both Mr. Rink and Mr. Burnett, were kept standard, that would be as close to the standard car as would ever be approached.

The draft castings, arch bars, bolsters and some of the other parts should be standardized to a greater extent than at present. It was absurd that the slight variations in these parts necessitated their being obtained from the car owners when repairs were made on foreign lines.

Mr. Vaughan thought that Mr. Rink was not quite fair to the Canadian Pacific Railway in his illustration of type H underframe (Fig. 28). The diagram showed the underframe without any cover plate, the bolster and the two 15-in. channels running through. The company did intentionally employ a cover plate running about 5 ft. long from the back of the draft casting to about 3 ft. back of the bolster underneath the sill.

Between the bolsters and the sills, the cars were practically unsupported except for side bracing. Mr. Vaughan stated he would not advocate this construction if the Canadian Pacific cars were running in heavy coal trains or under such conditions as the Norfolk & Western have in their coal service. In designing a car it was necessary to figure on the service the car was generally going to run in, not the service it might run in. It was felt that 60 per cent to 75 per cent of the service to which the box cars were put, both in Canada and the United States, was service in which the old type of underframe would stand up satisfactorily. These figures were justified by the result obtained with this type of car, in a period of five years, as given in Mr. Burnett's figures.

As far as was known, not a single car had shown vertical weakness in the center sills. The omission of that cover plate had introduced a certain amount of longitudinal weakness through the center, as well as buckling sidewise, but in no case buckling vertically. It was thought that the floor would be sufficiently stiff to prevent any lateral buckling

of the center sill, and some floors were so loose that they could not have acted that way if the car had been permitted to buckle. The center sills and the side sills had ample strength to hold up the corners of the cars under general conditions, and the saving of 500 lb. of weight there, 500 lb. in the cover plate, and a few hundred pounds here and there, was what had made so light a car. The company had a car weighing 36,500 lb., carrying 40 tons, which could be loaded to 93,000 lb., permissible loading.

Mr. Vaughan called attention to the advantage of reduced weight on net earnings, and not on the cost per ton-mile; the company's figures for 1913 showed that 22.34 tons per loaded car-mile were carried, and that the percentage of light car mileage was 28.5 per cent of the loaded car mileage, which gave an average load of 16.8 tons per car-mile total. The weight of the average car unloaded was 18 tons, so that the average weight of car loaded was 34.8 tons. That was not a bad figure for a large number of roads in this country handling general traffic. The Canadian Pacific handled a large amount of grain, and while it did not have much coal, the average load was fairly good.

Assuming this average car weighed 1 ton more, to begin with, without any question as to whether the train rating would always be changed or not, the weight of the car loaded would go up to 35.8 instead of 34.8; in other words there would be an increase of the ton mileage of 2.85 per cent; or if operating on a ratio of 70 per cent, under this changed condition of weight, the operating ratio would be 72 per cent instead of 70 per cent. The net earnings would drop from 30 per cent to 28 per cent, which was a difference of 6 per cent in net earnings.

The question of weight was an important one in car design. A lighter car might cost $5 or $10 more a year to keep up than a heavier one, but it would save two or three times that in the weight to be hauled uselessly about.

Mr. Vaughan agreed with Mr. Rink in the question of sheathing. The Canadian Pacific owned a number of cars which had shrunk considerably, but there had been few cases of damage cases due to them. It was not a difficult matter to tighten them, as Mr. Burnett said, and the only reason why this had not been done was because the company had not received a sufficient number of complaints to justify taking the cars out of service and doing the work. The vertical sheathing would be, possibly, a preferable arrangement if it could be accompanied with an economical and convenient design of side framing. But this would be difficult to accomplish for the truss form of side framing naturally lent itself to horizontal sheathing. In vertical sheathing horizontal members would have had to have been introduced to take care of the fastenings, as in the Pennsylvania Railroad cars. The distance from the top plate to the sill was too great to permit the side sheathing to be placed vertically without any support.

Fig. 14 Inside Sheathed Steel Frame Car used by the Intercolonial Railway (36 Ft., 30 Ton)

Mr. Rink referred to end reinforcement repairs. The Canadian Pacific Railway were using very extensively the same style end as was used on the steel frame car for repairs of all wooden box cars: it simply put in two Z-bars and reinforced the ordinary end post, and put the $1\frac{3}{4}$-in. lining inside.

He thought the roof question was the next to come up for discussion: the three types described were at present the most widely used. The Canadian Pacific had been an advocate of the inside metal roof for a long time, though they had experimented with the all metal roof, and would be interested to know what results were being obtained.

Mr. Vaughan in discussing the history and the develop-

ment of this type of car, said he felt that he was correct in saying that this type had been originated on the Canadian Pacific Railway when W. E. Fowler was General Master Car Builder. The car was the result of a conversation between Mr. Fowler and Mr. Vaughan relative to policy in turning toward steel underframes.

B. D. Lockwood stated that if Mr. Rink's recommendations advocating standardization of cars were to be followed a committee should be appointed by the Society to design such standards, indicating in their work the minimum of strength and empty weight and the reasons therefor that should be acceptable from a railroad standpoint, so that car builders could govern their action properly in competition. The joint efforts of the railroad committee of the Master Car Builders Association and the United States Railway Mail Service in connection with the standardization of postal cars resulted in a series of recommendations, and the adoption afterward, of standard specifications, in which the minimum acceptable section moduli was given as the governing factor for all principal members and there was no reason why this could not be done in the case of recommended standards for freight cars.

Mr. Rink had outlined a system of calculations, but whether his deductions were to be considered as generally expressing the ideas of railroad mechanical engineers throughout the country was a question, and the whole matter should properly be referred to a committee.

H. Wade Hibbard called particular attention to the necessity of designers keeping in close touch with service conditions. A number of years ago he was connected with a large trunk line, where it was the declared policy in the mechanical department that the designers should go frequently into the shops and into the repair yards and into the scrap yards for the purpose of studying how the equipment had failed in service. Later the policy was changed and the men were not expected to carry on that sort of close contact with the service conditions, with the result that locomotives that were found at the main shops to be bad in design for upkeep were reordered from the locomotive builders with the same old mistaken design. The policy of one of the large steel car manufacturers of the country was a good one: they had a college educated man go into the shops and learn the business completely; he afterwards was kept traveling among the railroads that purchased steel cars from his company for the sole purpose of learning the good and bad things about these cars in actual service, reporting the result of his efforts to his company.

W. F. Kiesel, Jr. (written). There is one feature in the calculations for end strength to which Mr. Rink has not especially called attention, and that is the ratio of stress to strain under end shock. The important point to consider is that at the bolster. This ratio in the 14 cars enumerated varies between 0.033 and 0.118. The high figures are due to the great distance between the center line of the drawbar and the neutral axis of the sills. The area of the center sills at the bolster varied from 19.08 to 36.18, and the average is 24.75. Without using any additional metal in the center sills the ratio of stress to strain can readily be reduced in many of these cars to the advantage of the strength of the car.

Both Messrs. Burnett and Rink seem to favor the Z-bar posts and braces because they are made of rolled material, and, as stated by them, can be readily obtained. This does not seem to be a good argument, as it is well known that standard sections of rolled material cannot always be obtained on short notice; in fact, within the past year, the steel mills have quite frequently reported that certain angles, I-beams, etc., could not be furnished in less than three or six months.

The four following questions seem important: First, is the box car with steel side frames all that it should be? It has been argued that shrinkage of lining, driving of nails in lining to secure blocking, breakage of tongues and grooves, etc., will cause leakage, necessitating constant repairs, and that the car with steel sheathing and wood lining is closer to the ideal in box car construction.

Second: in box cars without sheathing, shall all posts and braces be made of rolled steel, or all pressed steel? Advocates of pressed steel assert that pressed posts and braces are lighter per unit of strength, because they can be formed to the required shape; that they can be formed with sufficient surface at the ends for the number of rivets required to develop their full strength, whilst Z-bars and other rolled forms require gusset plates for this purpose; that they are not likely to be damaged by push-poles, and, if damaged in wrecks, can be readily straightened and restored to approximate shape; that when absolutely necessary to replace them they can readily be obtained from car owner or builder, and that it will not be necessary to wait for any special rolling of material.

Third: should not the posts and braces be considered strictly as beams supported at top and bottom, in combination with straight tension and compression, as members of the side truss? Mr. Rink indicated that flattening of pressed posts and braces, where they connect with side sills, has a weakening effect, which further indicates that he considers them as cantilevers held in vertical position by the side sills and frame braces connected thereto. In wooden cars the posts and braces were strictly beams, and not cantilevers, as they rested on top of the side sills, either directly or on castings with shallow pockets. Side sills of box cars have too little resistance against torsion to hold the posts and braces vertical; they, therefore, must depend on the strength of the side plate and the tying effect of the carline. If, in addition to this, a solidly riveted roof is used, the tops of the posts and braces are securely held in proper alignment and the stability of the side truss is assured.

Fourth: is it not imperative to use diagonal braces in the end framing? No argument need be presented here for this, as Mr. Rink has already furnished sufficient argument, and we know of nothing to show the contrary.

It should be noted that all of the 14 cars enumerated by Mr. Rink have so-called box-girder center sills, and that the majority of them have a minimum section of about 24 sq. in. With this section area a ratio of stress to strain of 0.06 can be obtained, provided proper adjustment is made for relative location of neutral axis of center sills and center line of draft gear. It would, therefore, seem that the present designs of box cars corroborate the recommendations of the Committee on Car Construction of the Master Car Builders' Association, and that those recommendations are reasonable and conservative. A thorough knowledge of cars by the motive power officials of railroad companies will, we hope, lead them ultimately to endorse the M. C. B. recommendations referred to.

E. G. CHENOWITH[1] (written). Before a standard for the box car is reached, it appears to me that three very important items entering into the problem must be decided upon in common by all railroads, viz: (*a*) capacity, (*b*) dimensions and (*c*) design. The railroad companies are far from agreeing on either one of these items, as can be seen from Messrs. Rink's and Burnett's papers. One need only stop to consider what an enormous saving there would be in maintenance if there was only one design of car to repair, and what a decrease would result in the enormous quantity of material which is now carried if our stores need carry repairs only, say for a 40 ft., 40-ton steel frame single-sheathed box car. Under this ideal condition our bad-order cars would be on the repair tracks 50 per cent less time.

The design of a car is influenced by many local conditions, and often by a great many local instructions. It is regretted that the merit of a design of a car is too often inversely proportioned to the final weight of the car. I believe that we are now about at the minimum limit relative to weight of box cars, and the tendency is to increase, and not worry so much about the extra dead weight hauled but to give more consideration to keeping the car in revenue service more days of its life.

Steel underframes are now being applied to thousands of cars in this country and perhaps in as many designs. Whether they should carry a vertical load, or only withstand the buffing, seems to be a prevailing question. Many underframes are being applied to cars retaining the original truss rods, while in many other cases the depth of the steel underframe is made to carry the vertical load, thus eliminating the truss rods, it being claimed that the cost of maintenance of rods will offset the cost of deeper center sills. It must be conceded that in a great majority of cases where any design of underframe is applied, the wooden underframe is not disturbed, so that, therefore, the weight of car is increased to an amount equal to the added steel underframe.

The main object in view in applying steel underframes is, I think, to obtain a greater resistance capacity for buffing. The car perhaps has with the aid of truss rods properly carried the vertical load, therefore, why not add to the underframe only that which will take care of the buffing strains. To my knowledge, underframes are being applied which consist of 8 in. by 8 in. H-girder beams. These girder beams set up between the wooden centersills, supporting them by means of angle brackets riveted to the flanges. To these girders the ½-in. draft plates are riveted extending from end sill to bolster. As this design was not intended to carry a vertical load, the bolster and cross ties were not connected to the girder in a manner to carry the load imposed on the side sills. Another cheap design of an underframe of this class lies in the use of two 9-in. channels with cover plate; this design sets below the wood sills, however, and therefore requires a bolster and cross tie in order properly to apply truss rods.

In the design of steel underframe consisting of two center members, it seems to be the general tendency to apply top cover plates instead of relying on the diagonal bracing to side sill to keep the center sill from distorting in very severe service.

Referring to Table 2, Mr. Rink states that it is the whim of the designer that occasions so many different lengths of box cars. In my experience in designing equipment for several different railway companies, the consideration of a proper length car was held as a serious question and good reasons were developed in the freight traffic department before the designer received instructions as to the principal dimensions around which to design a car. The popular dimension, it seems to me, for inside length of box car is 40 ft. I know of a railroad operating over 12,000 cars of this length and they seem to meet the requirements very well.

The standardization of design of box cars will have a tendency to decrease the great variation of weights. I saw two designs of cars built within a year of each other by two railway companies, one a 60,000 lb. capacity car having a light weight of 48,000 lb., while the other, an 80,000 lb. capacity car, had a light weight of 36,000 lb., and moreover, both railway companies were perfectly satisfied with their designs.

In the design of steel superstructure cars, I am of the opinion that the side sills should be only of a proper section to complete the trussed panels of superstructure, and should not be designed as a load carrying member. This will allow the superstructure more flexibility to adjust itself to irregularities of track and eliminate the tendency to derail. A car held rigid so that the planes of the sides are always parallel will not properly take a curve.

The trouble experienced from water following beading or grooves in horizontal sheathing and then passing into the car, could, I think, readily be overcome by bevelling off the top corner of each board outside of the tongue, which would eliminate the gutter effect at points of matching where the sheathing is not entirely tight. Where single sheathing is used the 1½ in. thickness seems to meet the requirements, and it should be tongued and grooved instead of shiplapped. Some designers are using 1¾ in. or even thicker for end sheathing, but the 1½ in. thickness on both sides and ends with extra reinforcement on ends furnished by proper design and location of end posts seem preferable.

The proper method of designing the end of a box car or reinforcing it for shifting loads is a question all designers have given extra time and thought. The end posts of a car are of no consequence except in so far as the end plates, of whatever construction, can properly support the upper end of the posts. This evidently has been overlooked in some cases, as cars will be found having heavy steel end posts attached at top to a light wooden end plate. The end of the car should be so constructed as to resist going in as well as bulging out.

As the author stated, of all the things which should be made standard, a box car side door is one of the most important, and should be the easiest standard to obtain and maintain. Yet, few railroads have cars of different series which have doors interchangeable. I believe in the use of a roller at the top of the door and I am now experimenting with rollers at the top, and with one of the door guides at the bottom equipped with a roller. This will assist in holding the door in place, and I believe will make the door operate much more easily; it will also stop the use of a steel bar for prying the door open or closed. No mention is made in the papers of either a flush or an inside door; both types are being advocated.

There are many designs of steel carlines, and while some answer the purpose for which they were designed, others are unsatisfactory. The tendency is to figure a carline for

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strength at the center, forgetting the section near the side plate. One function of the carline is to keep the side plate from spreading out as well as coming in, and therefore, should not be designed to support the roof alone. I had the occasion not long ago to inspect a steel carline which had ample depth at the center, but at the ends a part of it was bent at right angles and riveted to the inside of the side plate angle, so as not to furnish any resistance to the side plate going out. I am of the opinion, that if need be, we should sacrifice head room to get carlines nearly straight on the bottom edge, which will act as a tie rod in tension and be in best of shape to withstand compression.

The draft gear and its application to the car are the most important details of any car; yet while this fact is appreciated by all railroad men, a great diversity of opinion exists among them as to what is best. Many are holding to a spring gear, while others claim that the friction gear is a "life saver." Does the good obtained from the use of friction gear warrant the extra expense? There should be a minimum allowable area for draft sills, which should be effective and well balanced about the center line of draft. I have often wished that the standard drawbar height was increased at least 1 in., which would allow a better application of the high capacity draft gears.

The steel frame box car with single sheathing has, I believe, come to stay, with some modification, perhaps, in the general design, to overcome weaknesses which may develop in years of severe service.

C. A. Seley[1] (written). I acknowledge with many thanks the compliment paid me in the second paragraph of Mr. Burnett's paper; my connection with the development of composite freight car construction was very interesting and a deeply appreciated opportunity in working out that step in the evolution of car construction. About 15 years ago three factors influenced some progressive railroads to the larger introduction of steel in framework of freight cars: increased capacities, greater structural strength to withstand operating stresses, and the approaching equalization of costs of steel and car lumber, particularly for framing.

For new cars, I believe there is now no good argument against steel for the complete framing, so combined that the sides will assist in carrying the load. The question then arises as to how far to go with the use of steel for such parts of the car as merely contain or shelter the load. Manifestly, floors must continue to be made of wood to enable blocking of the lading. Aside from this there are many predictions of all-steel box cars. In my opinion this will be the ultimate construction, but doubtless slow in general adoption on account of the still favorable balance in favor of the cost of wood for lining and sheathing, and in combination with steel plate for roofing, whether of the so-called outside or inside type. When the all-steel box car does come, it will have to be arranged with ventilation features to prevent damage to lading from sweating and from accumulation of excessive heat which may unfavorably affect many high-grade commodities if shut up in a steel box without such ventilation.

The Canadian Pacific Ry. is to be congratulated as being the pioneer in developing the inside sheathed box car, and judging from the record as stated by Mr. Burnett, and giving due weight to the statement that "practically no reports of loss or damage to lading due to shrinking" being received, that construction would seem to be fully justified when proper lumber and care in building are used.

Both authors have discussed the advisability of the standard car. I doubt very much if this idea will ever be consummated, even to the extent of the standard material idea advanced by Mr. Burnett. The difficulty in the way is the human element; if we all thought alike it would be possible. The Master Car Builders Association has standardized the parts essential to interchange, and under this head may be listed couplers, air hose, wheels, axles, journal boxes and contained parts, brake shoes and brake gear parts. The Government has standardized safety appliances. This to the uninitiated would seem to settle most of the difficulties in car repairs, but we all know that very few of the Master Car Builders' standards are really standard in exact detail, and the Interstate Commerce Commission safety appliances necessarily give considerable range of dimensions and application within which their requirements may be fulfilled.

It is difficult for one not in railroad service to appreciate the whole problem, and particularly the influence of interchange requirements. A railroad may be of low gradient, equipped with light power, and have a class of traffic that would ordinarily keep their cars on their own line, and the cars which would most economically fulfil all requirements for such a line and service can be readily imagined. In interchange, however, these cars might be required to go anywhere from coast to coast, in all kinds of tonnage trains, through hump yard trials and other tribulations never experienced on the parent road.

Furthermore, a railroad car designer can never afford to worship standards in view of the rapid evolution in transportation. This may be illustrated by the progress of the Master Car Builders Association in adopting standards for car axles. The 3¾ in. by 7 in. axle for 40,000 lb. capacity car was standardized in 1873; the 4¼ in. by 8 in. axle for 60,000 lb. capacity car followed in 1889, a lapse of 16 years; then in only seven years, the 5 in. by 9 in. axle for 80,000 lb. capacity car was standardized in 1896; and that was followed in 1899 by the 5½ in. by 10 in. axle for 100,000 lb. capacity cars, and the end is not yet. The only limit is the gage and endurance of rails for wheel loads, and all above the rail must be proportioned to the stresses.

O. C. Cromwell[1] (written). Referring to Mr. Burnett's design of steel upper frame box car I observe that no diagonal braces are used in the end framing of the car, such as are generally used in the end of a wooden frame car. These braces tend to keep the end framing of the car square, and while their omission would probably not be apparent for the early life of the car, would it not be expected, as the car ages, to find a loosening up of the riveted joints uniting the posts with the plates and underframe? While the car is new, the end sheathing will serve to keep the framing straight, but will not these end boards loosen up in time through shrinkage?

The paper states that the lumber in these cars is very carefully selected, only specially dried lumber being used. When the car is new, this, of course, tends to keep the framing square, but as this class of car becomes more numerous, there will be a letting up in this feature of obtaining specially

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[1] Mechanical Engineer, Baltimore & Ohio R. R. Co., Baltimore, Md.

dried lumber, and the shrinkage of the boards will be more pronounced, and their effect as a brace will become less efficient. Also we know that on gondola cars the side planks decay under the side stakes and under the corner bands. Would not a similar action of the lumber be expected in this character of car as time went on? Would not this, in turn, lead up to the loosening of the framing? Also will there not be a tendency for water to get into the planks through the bolt holes and start decay?

The irregular distribution of the loading in cars throws twists into the superstructure, and this has a tendency to rack loose the riveted joints. Also, the jacking up of cars to remove the wheels from the trucks throws similar strains into the framing.

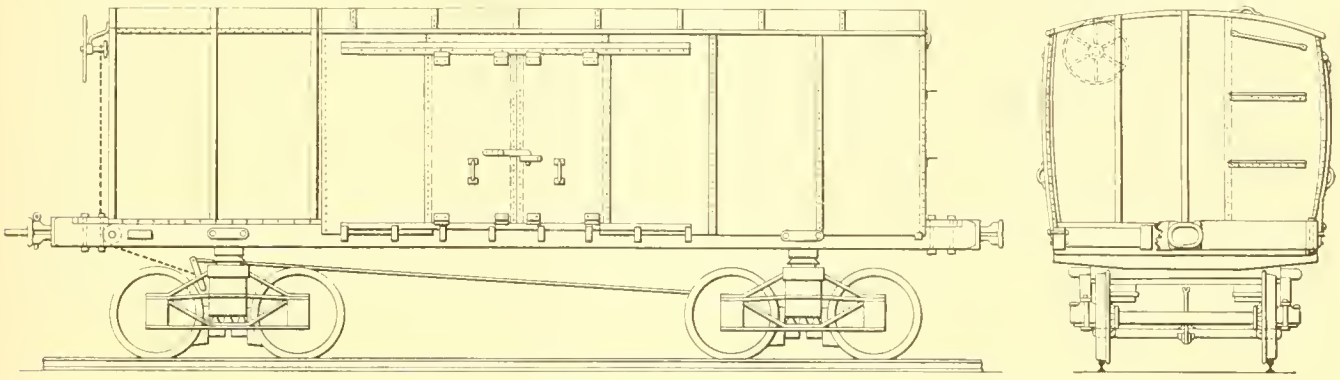
Provision has been made in this car for taking up the shrinkage in the sheathing by providing slotted bolt holes in the framing for securing the bolts holding the sheathing in place. By slacking up these bolts and straining down the tie rods, the boards are to be drawn to tight joints. Recently I had an opportunity to look over the outside frame box cars of another line, and found that they were not using the slotted bolt holes above referred to, and upon inquiry, was informed that these boards could not always be drawn tight by the use of tie rods, and that since they would not shift into place by the use of the tie rods, their use could well be dispensed with.

I would like to inquire if there is any provision made to forestall the tendency of sheathing to decay back of the posts and braces. At one time, the Baltimore and Ohio operated some outside wooden frame box cars with inside sheathing running longitudinally, and considerable trouble was experienced with the sheathing deteriorating or rotting back of the posts and braces. There was also considerable trouble in maintaining the superstructure of these cars in a square condition, and a different form of roof bracing construction had to be resorted to. I would be interested to learn if the outside steel frame cars are a little later on going to develop the same peculiarity as to rotting of the sheathing that developed in the old wooden cars.

I understand that the joints in the boards are tongued and grooved, and I have been informed that on some of them the tongues and grooves are made a little deeper than is usual in order to insure against opening to the weather in the event of the boards shrinking. In case the boards shrink, being in a horizontal direction, has there been any trouble, during driving rains, with the water being driven around the ends of the boards and working into the inside of the car? I would like to inquire if anyone has had any experience with other forms of board joints than the tongue and groove?

Recently we have seen the introduction of steel ends to wooden frame box cars, and it occurred to me in connection with the end framing for steel outside frame box cars, that notwithstanding the fact that the $1\frac{3}{4}$ in. thick boards were used in the ends, these boards will be broken out by the shifting of the loads, and the application of the steel plates to the ends of the cars would protect the boards, and act as a stiffener to the end of the car. Possibly this phase of the question may have been given some consideration and it is mentioned at this time in order to bring out this feature.

Has there been observed any tendency for the sheathing boards to swell, due to the changes in weather conditions? I believe that it has been the general experience that when kiln-dried sheathing is applied to box cars, and driven up too tightly, trouble will result in damp weather with the boards swelling, and the sides of the car buckling. This is experienced with narrow widths of sheathing applied vertically. With sheathing of wider widths of boards laid horizontally, in which the moisture is retained longer, would it not be expected that there would be more swelling of the lumber, and for this reason, it may be that the slotted holes in the posts for securing the sheathing are useful more for the purpose of taking care of the swelling and shrinking of the lumber than for taking up any wear.



Design of Iron Box Car built by the Baltimore & Ohio R. R. in 1862

I believe that there are some outside frame cars in which the siding is applied vertically; I trust that there will be some points brought out in regard to this paper that will give some light on the advantages and disadvantages of the two methods of applying the sheathing.

Referring to the corrugated steel lining used instead of lumber for sheathing, the Baltimore and Ohio Railroad in 1862 built some iron box cars, which had wooden underframes, but the body and roof of iron plates. The illustration shows one of these cars that had a body 21 ft. $1\frac{1}{4}$ in. long, 8 ft. 2 in. wide, and about 6 ft. 6 in. high. The side and end plates were $\frac{5}{16}$ in. sheets, applied vertically, the sheets being about 37 in. wide, and the roof sheets about 32 in. wide, all sheets being riveted together at the joints. The sides were slightly convex to give them stiffness, as was also the roof, but the end plates were applied perfectly straight. The sides, ends and roof were stiffened with 2 in. by 2 in. ribs of ash. These cars proved unsatisfactory, because in summer they became so excessively heated that they spoiled the merchandise, and in sudden changes of weather, produced sweating, with damage to lading, and the cars had to be finally withdrawn from

service, and used for special trade, and were ultimately converted into workmen's storage sheds, tool houses, etc. I would be interested to know if any of the corrugated iron cars have shown up any of these defects.

Referring to Mr. Rink's paper, the several tables bring out the principal dimensions in comparison very clearly, and in looking them over, one is impressed that in the main, the dimensions are very close, and that it would need only the guiding influence of some association to eliminate these variations to bring them within very much narrower limits. The metal parts, rolled shapes, etc., used in the construction of these cars, could be found in the stock of any railroad, in case the cars were damaged or needed repairs.

The side posts and end posts, side braces and end braces, corner posts and door posts, should be brought down to a standard; they are now very nearly this, as shown in the tables. The side posts, Table 4, are of the same dimensions for all the cars, except in the case of the 4-in. pressed steel shape, while there is only a slight variation in the side braces, and they should be easily reconciled. Several different cars have the same corner posts, and as they are very much exposed members, it is important that they be alike on all cars. Table 6 shows that the end posts are very close, and have very little variation.

The point brought out in Mr. Rink's paper, with reference to the height of the floor above the rail is certainly an important one, and it appears to me that there is no good reason why we should have a variation of 6¾ in. in this height, as brought out in Table 7; this, too, affects largely the height of the truck. As it is desired to work towards standard and interchangeable truck parts, the height of the truck is an important one to bear in mind.

W. S. Atwood (written). The first steel frame box cars built by the Canadian Car & Foundry Company were considerably heavier than those now being built. The car referred to in Fig. 1 of Mr. Burnett's paper weighed 41,200 lb.; this, of course, was partly due to the fact that the car was constructed from stock material, no special material having been ordered. In fact, the side braces and posts were made of heavy angles in place of the light Z-bars, as at present in use and as originally intended. There are several details which have been changed from time to time in order further to increase the efficiency of the car. These details have also had a tendency to lighten the weight, so that now a car weighs less than 37,000 lb.

Referring to the grading of the lumber, with the first cars of this type, there was some difficulty experienced in securing the proper grade of lumber and also in properly drying it for application to this type of car, as owing to the thickness, the lumber had to remain in the dry kilns longer than was necessary in the case of the thinner sheathing used on the outside sheathed car, and on this account the car companies were not, in all cases, equipped with sufficient dry kiln capacity. The lumber dealers, however, have met the car builders in attempting to prepare a satisfactory grade of lumber for these cars and no difficulty whatever is encountered at the present time in getting an adequate supply of a satisfactory grade.

As to the allowance for finishing, in the first lot of cars built by the Canadian Car & Foundry Company, owing to the condition of the lumber it was necessary to use, it was thought advisable to purchase 6 in. stuff to finish 5 in. face, but owing to the amount of this grade of lumber which has been used in the last two or three years, it is now possible to get a satisfactory grade, purchasing 6 in. stuff to finish 5¼ in. face, which makes possible quite a saving on a large order of cars.

Judging from the service which this type of car has given to date, and also from the favorable criticism it has received from practical railway men, it would seem that it would eventually replace the outside sheathed car, and owing to the simplicity of the design it would seem possible for the railways to adopt a standard car of this type in so far as the general dimensions and sections are concerned. The adoption of a car with standard inside dimensions and outside clearances would be a matter of considerable importance to the car builders, as material could be stocked and available for building cars required for quick delivery for any of the railways which had adopted this type of car. It would also allow them to place large orders for the inside sheathing which could be prepared and stored a sufficient length of time to make it entirely suitable for this type of car and eliminate any possibility of trouble from shrinkage.

From Mr. Burnett's experience with one of these cars lined with corrugated steel, and also from the experience which others have had with steel lined box cars, it would seem only a question of time until the wood inside sheathing would be replaced with steel. I also believe that, in addition to the lining eventually being made of steel on these cars, some type of all steel roof will also be adopted, thus eliminating wood entirely, with the possible exception of the flooring.

I do not agree entirely with Mr. Rink in his statement that engineers did not understand the importance of low fiber stresses in the early designs of steel underframes. There is no question about this not receiving the same attention in the early designs as it is receiving at the present time, but I think that the desirability of showing as favorable a cost and weight of the all steel and steel underframe cars as against the all wood cars had a great deal of influence on the early designers. Since these early designs have gone into service a great deal of information has been accumulated in regard to these stresses and the importance of strong construction is now receiving more consideration, so that there is not the same comparison made between the steel car and the wooden car as was made by the early advocates of steel car construction.

The statement of Mr. Rink, that vertical sheathing is preferable to horizontal on account of its protecting the lading against water, is hardly borne out by the results which have been obtained with cars with the horizontal sheathing. With cars constructed with a suitable grade of lumber and with reasonable care at the joints, there should be no possibility of the lading becoming damaged with water. In fact, upon inquiry from officials who have several thousand of these cars in service not one complaint was known to have been received where the water had damaged the lading. I think the horizontal sheathing has many advantages over the vertical.

The advantages that Mr. Rink shows would result from all the roads having cars built of this type using uniform sizes of material cannot be emphasized too much. If any large number of railways using this type of car could agree on a uniform inside dimension and a uniform size of sheathing, it would certainly facilitate the procuring of material

and would result in eventual benefit to the railways. It would enable the car builders to arrange with the lumber manufacturers for large supplies of this particular lumber, which could be thoroughly dried and satisfactory for use, thus eliminating any need of rushing the material through the kilns in cases of short delivery.

On the first cars of this type, the diagonal braces in the end panels, which Mr. Rink refers to, were applied but owing to the stiffness given to the frame from the heavy inside sheathing used, both the side brace and the end braces were omitted after the first few cars were built. There has been no trouble experienced from insufficient support for the corners of the car and by using the end braces as verticals the advantages against protection from shifting loads would warrant, I think, their being used in this way instead of as braces. The corner of this type of car at the eaves gets a great deal of support from both the side and end lining and judging from the service which cars have given under my observation, it would seem that this support was ample.

I would heartily favor Mr. Rink's recommendation as to the use of door hangers with rollers and to convince one of the desirability of this feature one would only have to put in a little time at the freight sheds and see the difficulty which is experienced in opening a large number of side doors.

As regards the standard height from the rail to the top of the floor, I think there is no dimension in the construction of the car which it is more important to have uniform than this, in order to facilitate as much as possible the unloading of box cars at platforms and also to facilitate their being used as runways when placed between tracks from which freight is to be transferred.

F. M. Whyte (written). Both papers touch upon the subject of car roofs directly and, in addition, refer incidentally to conditions which affect roof design and maintenance. The steel underframe is getting to be pretty well understood and is quite universally used, and information about the steel upper frame is accumulating rapidly so that it is fair to presume that the remaining part of the box car, the roof, will be given more careful consideration in the near future.

In Mr. Rink's paper, mention is made of possible loose rods, posts and braces, having a serious effect upon the roofs by permitting too much weaving of the upper structure, while in Mr. Burnett's paper it is explained that some twisting of the car body is desirable to permit the car to adjust itself to uneven track; apparently some weaving of the body is desirable and yet it is possible to have too much, which is believed to be the general opinion of those who have given consideration to the subject. However, independent of this concededly necessary weaving of the body of the car as a whole, the end framing needs, from the standpoint of the general framing and from that of the roof, more consideration than has been given to it. The end plate is a very important member of the body framing; it ties together the ends of the side plates; it receives a large proportion of the shocks given to the end posts by the shifting of the loading; and it receives the momentum of running boards, brackets and ridge pole when the car is suddenly started or stopped. Further than this, in many of the designs of end framing shown in Mr. Rink's paper, the outer ends of the end plate act as cantilevers in assisting to transfer the load on the ends of the side sills to the center sills through the end posts. The important exceptions to this condition are those designs shown in Figs. 19, 20, 24 and 25, in which the diagonal bracing extends from the bottom of the center posts to the top of the corner posts, Fig. 25, showing the end framing recommended by the Master Car Builders Association committee.

The end plate is also an important part of the roof proper because in all types of roofs some member of the roof is attached to the end plates. As more attention is given to the roofs in the future it is probable that something will be done to the side and end-framing which will assist the roof. There are a few railroad men who think that the roof, meaning that part which sheds water and carries the roof loads, can be safely used to assist in keeping the rectangular box of the car body in proper shape, but a great majority think that this is quite impossible, at least within reasonable weights for the roof. It seems much better, from an operating standpoint and from the standpoint of weights, to permit the body to weave more or less and to provide a flexible roof to cover it.

There is no very good reason for the confusion which appears to exist concerning what constitutes the roof; aside from the carlines, the roof proper is the material used to support the roof loads and to shed water. With the inside roof, the outside roof, and the roof with two courses of boards and a course of felt between them, the roof boards are quite as essential as are the steel plates in the first two, and the felt in the last one, and when the roof boards are damaged the *roof* is damaged. Mr. Rink says that the inside roofing sheets should last for a good many years if the roof boards are replaced every four years; this means that the life of the roof as a whole is four years. The roof boards cost about as much as the roofing sheets and too frequently this fact is overlooked.

Concerning the weights of roofs, the double board roof with felt between weighs the most; as between the inside and outside roofs with the same thickness of steel, the inside will generally weigh somewhat more than the outside roof on account of the additional framing necessary to support the roof boards above the metal sheets of the inside roof. However, the weight per square foot throughout the car, is practically the same for both; the all steel made of No. 16, U. S. gage will weigh least. An all steel roof of plates ⅛ in. thick, referred to by Mr. Rink, would weigh more than either the inside or outside roofs with No. 22 U. S. gage steel roofing sheets, but the thickest sheets of which the writer knows is 3/32 in., which would weigh somewhat less per sq. ft. than the inside or outside roofs even though the latter have roofing sheets of No. 26 U. S. gage. The No. 24 U. S. gage sheets are generally used for either the inside or the outside roof and as it is the mean of the two extremes of No. 22 and No. 26, referred to by Mr. Rink, it will be used in the following comparative weights.

Considering roughly that the area of the roof is 400 sq. ft. and neglecting additional thicknesses in joints, covering strips, etc., the weights per roof would be about as follows: double board roof, 2640 lb.; inside or outside roof No. 24, U. S. gage sheet, 1728 lb.; all steel No. 16 U. S. gage, 1020 lb.; all steel 3-32 in. thick, 1530 lb.; and all steel ⅛ in. thick 2040 lb. Thus the all steel roof of No. 16 U. S. gage steel will weigh about 700 lb. less than the inside or outside roofs with No. 24 U. S. gage roofing sheets.

There is also considerable misunderstanding about the first cost of various types of roofs, whereas under present conditions, there is not much difference in the costs of the various types. With the double board roof the extra course of boards and the felt will cost about the same as the metal sheets of the inside and outside types. The all steel types with No. 16 U. S. gage galvanized steel or 3-32 in. black steel will cost little, if any, more than the other types. However, considering the ultimate cost to the railroad company, it is necessary to go somewhat deeper than the first cost of the roof; for instance, Mr. Vaughan has said in the discussion of these papers, that it costs $12 per ton per year for hauling, but some prominent railroads put this cost as high as $22 per ton per year; however, if the mean of these, namely $17, is accepted it will be understood how important it is to reduce to a minimum, the material used to turn water and to carry the weight of a man or two. The cost per year for hauling 1000 lb., whether the rate per ton per year be $12 or $17, will more than pay the interest on the total cost of any of the present types of roofs including the carlines; this fact ought to impress those who are interested in ultimate costs.

Another item in connection with the roof which affects to a considerable extent the total cost of the car is the total thickness of the roof including the roofing material and the carlines and the manner in which the carlines are attached to the side plates. There is no good reason why the distance from the top of the floor to the top of the side plates should not be the inside clearance height of the car; nevertheless, in many instances the under face of the carlines is placed 3 in. to 4 in. below the top of the side plates and in such designs, the side and end framing and sheathing are the same 3 in. to 4 in. longer than necessary and entirely needless weight is added thereby, frequently to the amount of 300 lb. to 400 lb.

George W. Rink. The discussion has brought out some interesting facts, and in some cases a difference of opinion still exists as to the advisability of a standard box car. While it is true, as mentioned by Mr. Seley, that the capacity of freight cars has materially changed since 1873, we have reached a stage of development wherein it would be of immense benefit to all concerned if one standard type of car were to be purchasd by all railroads, this design to remain standard until changes are required to permit of reinforcing some detail, found by experience necessary to modify. A number of railroads are now having cars built from practically the same designs developed by them as far back as four or five years ago, these cars giving excellent results in service. It is true that changes must be made from time to time, but they can be made along standard lines by a representative committee of railroad men assigned for this purpose. Suppose it was decided, after building a standard car for several years, that a radical change in design was necessary, some benefit would certainly be derived in having all cars purchased in that period built along the same standard lines.

The omission of the short cover plate behind the bolster in the illustration of type *H* underframe in Fig. 28 of the advance pamphlets, to which Mr. Vaughan called attention, was unintentional, and has been corrected in this publication of the paper. I am much in favor of the steel upperframe box car; and from the information contained in the discussion, it appears that the horizontal sheathing is giving excellent results, and no doubt is preferable for use with the style of side frames built on the lines of the Canadian Pacific, Rock Island and other railroads.

My object in tabulating the sizes of various members of the box car, particularly the steel upperframe car, was to call attention to the small variations in weight and size of material which exist at the present day; and as mentioned by Mr. Kiesel, this material is difficult to obtain on short notice, and more attention should be given such details, with a view of using only standard materials which it will pay the manufacturers to keep on hand.

H. H. Vaughan in closing for Mr. Burnett said that he felt the author was correct in that it was not a question of how long it took to get structural material, but that it was a quesion of not having to get material at all. It was very rare that structural material was required for repairs on the steel superstructure car. If the car was side swiped, which was one of the worst forms of damage, it was only a question of cutting the members apart, straightening them out and riveting them together again. The amount of material required in repairs of steel cars of any type was exceedingly small compared with the material required for repairing wooden cars, whether hoppers, box cars, or any other type. The only parts taken out were those that had been crowded together, or torn apart, and it was rare to find pieces torn apart under wrecks. As a rule they were in such shape that they could be cut apart and replaced.

As to the introduction of a standard car, Mr. Chenowith advocated a standard car, and then proceeded to describe a new type of car which he thought was an improvement over those in use. In the cars which Mr. Burnett called standard there was one change after another; little improvements were suggested as each lot of cars was built. The Canadian Pacific began building cars a couple of months ago, and improved them in the making by changing all the rivet spacings. It was found that the rivet spaces were inconvenient in many cases and they could be built much more easily by changing the rivet spaces. If a standard car were decided on tomorrow, the next order for cars would contain some improvements and changes. It seemed to Mr. Vaughan that the best plan was to follow standard parts and to use material easily obtainable. With steel construction, that question would largely take care of itself.

In answer to Mr. Cromwell, Mr. Vaughan said that a number of different joints were tested before the tongued and grooved joint was decided upon. This style of joint, also a joint with a steel piece inserted between the rabbet and lining running into a steel strip were experimented with. The tongued and grooved joint was found to be the best, however, in the experience of the Canadian Pacific Railway.

In reply to an inquiry as to whether or not the features of car were patented, Mr. Vaughan said that that was rather a difficult question: there were some patents on this type of car, but so far as he knew no one had ever paid any royalty on them, and he did not know of any important patents that covered the construction of this type of car.

R. W. Burnett. In closing I will make only a few remarks on some items not replied to by Mr. Vaughan or which were not fully covered in the paper.

Mr. Kiesel questions if it is advisable to use single sheathing on account of damage due to driving nails for securing blocking, etc. It is my observation that there is

nothing to fear from this source, as even our oldest cars of this type show no signs of causing trouble. This is also true concerning the absence of diagonal braces in end framing. These cars even when severely stressed, in accident, retain their squareness in end frame to a surprising degree.

If I understand Mr. Chenowith correctly, he considers that relieving the side frame of load stresses will render the car more flexible. I do not believe this would make any appreciable difference in the flexibility of the car. In his remarks concerning strength of end plates, I presume he has reference to that type of car using vertical sheathing, as horizontal sheathing assists the end plate very considerably in resisting the reaction of the end posts.

Mr. Cromwell's remarks on braces and end framing are answered in my reply to Mr. Chenowith, except that I may say it is needless to worry about twisting strains due to jacking car, as the twisting stresses received in a few miles' journey over track that has heaved, produces more racking than all the jacking the car would receive in a lifetime.

MEETINGS

SAN FRANCISCO, NOVEMBER 17

At a meeting of the San Francisco Section on November 17, the following committee was elected for the coming year: Robert T. Sibley, chairman, C. R. Weymouth, vice-chairman, C. T. Hutchinson, secretary, E. C. Jones and Thos. Morrin.

NEW YORK, JANUARY 9

The January meeting of the Society in New York was a joint meeting with the American Institute of Electrical Engineers and the American Electro-chemical Society, at which was held a symposium on the subject of Electrolytic Deposition of Metals. A paper was contributed by Lawrence Addicks, of the American Electro-chemical Society, on Limitations of the Problem of Electrolytic Deposition; another was presented by F. D. Newbury of the American Institute of Electrical Engineers on Sources of Direct Current for Electro-Chemical Processes; while H. E. Longwell, Mem.Am.Soc.M.E., read a paper on The Power Problem in the Electrolytic Deposition of Metals.

Mr. Addicks outlined, in the opening paper, the requirements of the problem involved in electro-deposition work and showed the extent to which practice has developed in this line in large refining plants. The difficulties encountered are now, more than ever before, mechanical in nature; Mr. Addicks divided these into nine classes and discussed each in detail.

Mr. Newbury, in the second paper, pointed out the difficulties involved in producing the low-voltage current used in electrolytic work in the quantities demanded in large plants. The various types of generating machinery for this purpose were discussed in detail and the limitations of each shown. Whereas the direct-current turbo-generator is available in relatively small units only and the unipolar generator unsatisfactory, on account of commutation trouble, Mr. Newbury points to the alternating current turbo-generator and convertor unit as the most practicable, on account of being economical, reliable and flexible, and at the same time adaptable to large units. He referred to the advantages of the combined alternating and direct current equipment also for use in waterpower plants.

Mr. Longwell, in the third paper, treated of the economies of the power production problem and discussed the advisability of refinements in equipment to secure greater economy, where the capital investment in the refinements might overweight the results obtained. He showed the advantages of steam power over the gas power plant of any type, a feature of which is the continuous requirement for steam to heat the electrolyte in the deposition tanks; this taken together with the presence of waste-heat boilers that are used in the reverberatory furnaces in some refining plants form a strong argument for the use of steam power. Mr. Longwell favored the steam turbine generating unit for most cases, and showed where the use of a complete expansion turbine is more desirable than a reciprocating engine and low-pressure turbine in combination, except in possibly favorable cases where reciprocating engine units are now in use. The turbine with gear-driven direct-current generator was discussed as a type of unit offering marked advantages for use in this particular field; this type was shown to have been used long enough under varying conditions to have thoroughly proven its reliability and efficiency. The paper also touched briefly on plant installation and operating costs.

PHILADELPHIA MEETING, JANUARY 17

A joint meeting of the Society with the Engineers Club of Philadelphia was held in that city on January 17. A dinner at the club preceded the meeting, at which the local committee entertained the speaker of the evening, G. R. Henderson.

Mr. Henderson read a paper on Recent Locomotive Development, illustrated with lantern slides, in which he showed that the changes of the last few years, consisting in the development of details, have been largely brought about by the necessity of taking care of greater tractive efforts as well as providing for the increased fuel consumption necessitated by the enlarged power of the locomotive. The steam reverse gear, the automatic stoker, the coal pusher, the power grate shaker, the pneumatic fire door, and numerous other developments had come into being in response to this demand. The use of oil has also enabled a larger quantity of steam to be generated with small physical effort on the part of the fireman, and the steam superheater has increased the volume of steam and incidentally the capacity of the boiler, so that now it is almost universally used on engines of high power.

NECROLOGY

HERMAN CHARLES MEINHOLTZ

Herman Charles Meinholtz was born February 7, 1868, in St. Louis, Mo., and died in the same city on December 24, 1913. Mr. Meinholtz was educated in the public schools of his native city and in 1883 entered the Manual Training School of Washington University, graduating in 1886. After a short service in the University's testing laboratory and later as timekeeper in the Shickle, Harrison and Howard Iron Works, he became an assistant draftsman for the Heine Safety Boiler Company of St. Louis. The com-

pany was then having its boilers built by contract and young Meinholtz was sent to inspect and accept the work. His keen observation, straightforwardness and courage were manifest in this service and brought him rapid advancement.

In 1892 he was made chief draftsman and in 1895 superintendent; in 1899 he was placed in charge of the company's first shop in St. Louis which he gradually improved and enlarged. In the meantime the Phoenixville shop was being developed and he utilized this opportunity for comparison when made vice-president in 1907, and worked out a design for a special Heine boiler shop which was built in 1909 at St. Louis and stands as a monument to his ability in practical design.

Mr. Meinholtz was a member of the Engineers Club of St. Louis. Since 1911 he had been a member of the Society's committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels, where his practical good sense and exact knowledge found full scope. His twenty-six years as designer and constructor securely fixes his work in the profession. E. D. M.

GEORGE T. INGERSOLL

George T. Ingersoll was born at Schenectady, N. Y., November 6, 1847. After receiving a public school education, he entered the Schenectady Locomotive Works as an apprentice machinist, where he remained four years. He then secured a position in the Illinois Central Railroad shops at Chicago, and after three years returned East to assist in the reconstruction of the shops of the New York Central Railroad at Syracuse. When this work was completed his company transferred him to West Albany. In 1876 Mr. Ingersoll was appointed under-sheriff of Schenectady County, a position which he filled for three years. Until 1883 he was engaged in delivering engines at the Schenectady Locomotive Works when he was made foreman of the company. In 1899 he was appointed superintendent of the Schenectady Water Works, a position he held for ten years. Mr. Ingersoll then retired from active life, and died at Worcester, N. Y., November 10, 1913.

EVERETT FLEET MORSE

Everett Fleet Morse, inventor of the Morse chain for bicycles and transmission of power, was born June 28, 1857, at Ithaca, N. Y., and died November 11, 1913. He received his early education in the public schools of Ithaca, and was graduated in the class of 1884 from Sibley College, Cornell University. From 1884 to 1890 he worked on the design of an automatic horse-drawn hay rake, perfected inventions in carriage springs, and also worked as solicitor of patents. He was inventor of the Morse thermo gage, an instrument for measuring the temper of steel, which had been adopted by the United States and German Bureaus of Standardization. Mr. Morse took a profound interest in public affairs and welfare, and was recently elected president of the Ithaca Hospital Association. He was also a member of the building committee of the new Ithaca City Hospital.

EDGAR PENNY

Edgar Penny, for many years connected with the ice machine and steam engine industry in Newburgh, N. Y., as well as the work of the Alberger Condenser Company, died in Auburn, N. Y., November 14, 1913. He was born in Port Jervis, N. Y., February 13, 1845, and came to Newburgh when a boy to learn the trade of machinist in the Highland Iron Works. When the Civil War broke out he enlisted in the United States Navy and saw service in the South. At the close of the war he continued on the warship as assistant engineer and visited Japan, China and other foreign ports. After three years he returned to Newburgh to take up his work with the Whitehill Engine and Pictet Ice Machine Company. He remained with this company for a few years and then went to Waynesboro, Pa., where for twelve years he was managing director and mechanical engineer of the Frick Company. That firm built an ice machine invented by Mr. Penny, which was known as the "Frick" or the "Eclipse." In 1895 he returned again to Newburgh and formed the Newburgh Ice Machine Company, of which he became the first president. A few years ago when the late Louis R. Alberger bought out the Newburgh Ice Machine and Engine Company, known later as the Alberger Pump and Condenser Company, Mr. Penny became its vice-president, retaining at the same time his position as general manager of the old company. Recently his duties had been lightened when he was made consulting engineer of his company.

HENRY SHOTWELL WOOD

Henry Shotwell Wood, one of the foremost consulting engineers on hydraulic dredging machinery in the country, was born in Philadelphia, Pa., December 18, 1860. He was a graduate of Swarthmore College in civil engineering in the class of 1883, and until 1885 acted as inspector of drawbridge machinery for the Pennsylvania Railroad. From 1887 to 1906 he was designer and inspector of a special contractors' plant for the San Francisco Bridge Company, at the same time designing and building hydraulic dredges for the New York Dredging Company and the Atlantic, Gulf and Pacific Company. Among the largest dredges that he designed and built were the 23-inch suction dredges, Manila and Geo. W. Catt, the 22-inch dredges, Washington and Julia, and the 20-inch dredges, Florida, Port Royal, Texas City, Champlain and Fort Edward. He was the engineer and eastern agent of the North American Dredging Company of California.

Mr. Wood was a member of the American Society of Civil Engineers. He died December 5, 1913.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

OWING to the wealth of material both in foreign periodicals and in the proceedings of engineering societies, some articles of interest had to be left unabstracted or abstracted only in part, to be taken care of in a later issue of The Journal.

THIS MONTH'S ARTICLES

A French military engineer solves the problem of safe flight by proposing a parachute that would protect both the aviator and his ship. A German engineer describes how a forge blower for duty, where reliability was the first consideration, was designed so that drawings and patterns of an old steam engine could be used in its construction. In the same section is reported an extensive investigation of a branched suction piping showing both the amount of air actually flowing through the various pipes in such a system, and the application of the Blaess method of equivalent openings to the design of large exhaustor systems.

In the section Internal-Combustion Engines, a calculation on the value of blast fuel and coke oven gas is reported, showing that with an output of less than 5,000,000 tons of pig iron per year, eastern and northern France disposes of a source of wealth in the coke oven and blast furnace gases, equivalent to approximately $24,000,000 per year. Tests of a peat suction gas producer are also reported: with poorly dried peat, the composition of the gas did not materially vary notwithstanding wide variations in load. Data on peat consumption are also given. Attention is also called to the inquiry started in France by *La Technique Moderne* on the operation of high efficiency heat engines. The important point of the predetermination of the dimensions of ports in two-stroke cycle oil engines is fully discussed. The author refers to what appears to be an interesting investigation of Kreglewski of which an abstract will be made as soon as the original text is received in this country.

The first part of the interesting article of F. Robin on case hardening is abstracted. Mr. Robin has done splendid work on heat treatment of metals and metallography and his opinions therefore are entitled to particular consideration.

The section Steam Engineering is especially rich in interesting material. O. Köchy reports a number of tests permitting of the establishment of the evaporation law for stationary boilers. Claassen describes a number of steam valves operated at a distance, by electric motors, electromagnets, water pressure surges, etc., as well as automatic mixing valves, constant pressure, constant temperature regulators, etc. Nerger gives data of tests made by the Prussian Railroad Administration in which locomotive smoke box cinders have been successfully burned under a boiler *without any addition of gas coal.* A description of the Missong engine, a single-cylinder compound engine with possibility of drawing-off receiver steam is given. The status of the steam turbine is being established in Germany, and Professor Josse draws a picture in bold lines, from data obtained from replies to a circular letter sent out by him to a number of turbine-driven central stations, showing the direction which the development of steam turbine engineering took there.

Wm. H. Kaempfer presents a full compilation of data with respect to air seasoning of timber. James P. Gillies, before the American Society of Brewing Technology, discusses the subject of compressed air pumping on the air lift system, on which, unfortunately, comparatively little information is available in an easily accessible form. E. N. Janson shows why marine shafting may sometimes be severely overstrained, even though apparently designed with proper margins of safety. H. C. Johnson, in a paper before the Concrete Institute, reports the results of tests on the Strength of Cement, while from a paper of the South African Institution of Engineers is abstracted an interesting discussion of the much neglected subject of saving of air power in the rock-drill operation.

Abstracts of articles on radium pyrometers, artificial rubber from coke oven gas, subway elevators, etc., will be found in various sections of the Survey. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

Aeronautics

AN AVIATION PARACHUTE (*Un parachute d'aviation,* E. C. *Revue industrielle,* vol. 44, no. 2112-47, p. 655, November 22, 1913. 1 p., 2 figs. *d*). A parachute must satisfy the following requirements: (*a*) when folded it must not affect the operation of the airship, which in turn must not hinder the unrolling of the parachute; (*b*) its unfolding must not produce effects of inertia dangerous for the aviator or for the safety of the parachute suspension, and (*c*) it must unfold fast enough to be available for use with comparatively small elevations. Captain Couade, of the French army, in conformity with these principles, designed *a parachute for saving both the aviator and the ship.* The parachute 1 (Fig.1) is enclosed in a tube 2 placed so as to open behind the rudder, and is provided at its end with a small tractor parachute 3, which alone projects from the tube. Usually this tractor is kept folded, but may be very rapidly opened by a single motion of the aviator. When opened, it draws the large parachute out of its sheath, and places it along the wind stream line. The area of the large parachute is calculated so as to give a velocity of descent of 6.50 m. To avoid excessive accelerations produced by the unrolling of the parachute when the ship is moving at great speed, a cable 4 is interposed between the suspension proper and the aeroplane, and a brake 5 is set in a manner such that the acceleration should not exceed a certain predetermined value; a shock absorber 6 affords the apparatus a still further protection from breakages due to too rapid action of the brake. When the tractor parachute 3 opens, it unrolls at first only a part of the large parachute, as shown by full lines; then the pressure of the air on 1 causes the string 7 to break, and the entire parachute unrolls. This gives to the parachute a more even action, and prevents excessive

gliding. Tests made with models have shown that the apparatus acts in a satisfactory manner. For speeds between 15 and 21 m (49.2 and 68.8 ft.), it has been found in two cases that the accelerations were in excess of

$$A_c = g\,\frac{Kr^2V^2 - (P+p)}{P+p+1.92gKr^2}$$

where A_c is the decelaration produced by the air on a projectile, according to the formula of Didion.

Air Machinery

Forge Blower (*Gebläse für Schmiedefeuer,* O. Klepal. *Die Fördertechnik*, vol. 6, no. 11, p. 262, 1½ pp., November 1913. 2 figs. *d*). Description of a curious forge

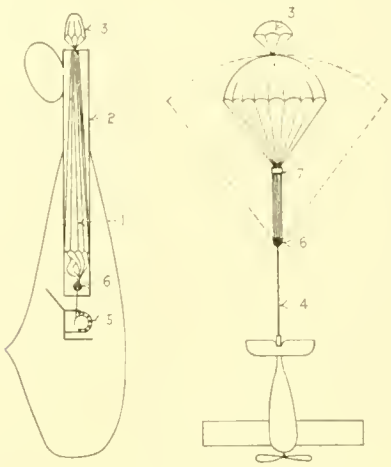


Fig. 1 Couade Parachute

blower in the construction of which were used, with only slight modifications, patterns and drawings of an old type steam engine designed for 8 atmospheres gage pressure. The blower was to be used in connection with the continuous production of hardened steel balls, and any interruption, either for repairs or adjustment, would be extremely inconvenient. In view of this, a very low volumetric efficiency (0.80 per cent) has been selected, so as to avoid as far as possible leakage at the valves. The use of the old steam engine drawings and patterns permitted the production of the blower at a saving of 13 per cent against what it would have cost otherwise.

Investigation of Air Distribution in a Branched Piping of an Exhauster Plant (*Untersuchung über die Luftverteilung einer verzweigten Exhaustoranlage,* D. Eie and H. Ovenberg. *Zeitschrift des Vereines deutscher Ingenieure,* vol. 57, no. 49, p. 1943. 3 pp., 4 figs. *eA*). Wherever a system of branched piping is required for the delivery of liquids, gases, and air to several places from a common source, the designing engineer has to determine the dimensions of the various pipes in a manner such that they might be able to carry the desired quantities at the given pressure head. This problem is often most important owing to the fact that once a system has been laid, there is very little chance for changing it if it should prove unsatisfactory.

The present investigation is of interest in view of the lack of published data concerning large exhauster systems carrying air at the average temperature and average pressure. The system described in the present article forms part of a large wood-working plant and has to carry out shavings and sawdust from the wood-working machines and metal dust from the fettling shop. The shavings and sawdust are taken up by the catcher at the place of origin, thoroughly mixed with air and drawn into the pipe where they are carried away on account of the large air velocity existing there.

The suction system, Fig. 3, consists of three main lines into which at various places lead 18 side lines. The three main lines unite shortly in front of the exhauster, from which extends a pressure pipe 16 m. (52.4 ft.) long and 500 mm. (19.6 in.) wide to the main pump. In order to avoid excessive pressure losses, the branches are connected to the main suction pipe at as small angles as possible. The experiment was carried on with pure air, all the machines standing still. During this investigation, the part from the quarter bend *a* to the pump was cut out, all the pipes were carefully cleaned, and the measurements made at the places indicated in the illustration by numbers enclosed in circles. In order to calculate the amount of air flowing through the main lines and through separate branches, the velocity was in each case measured at five points equally distributed over the cross-section of the pipe and the average velocity determined therefrom. The Krell dynamic disc, Fig. 2, was used for the measurement of velocity. In this apparatus there are two places at which the disc pipes join the manometer, so that the influence of static pressure is eliminated and the manometer indicates only the pressure difference proportional to the velocity head. In order to determine the constant a of the dynamic disc as given by the equation $v = a\sqrt{H_{st}}$, the author has measured the air flowing through a piping system by means of calibrated nozzles and found that the average value of the constant a is equal to 3.17. The velocities were determined by means of a micromanometer indicating pressures enlarged 9.7 times. Table 1 indicates the results of the in-

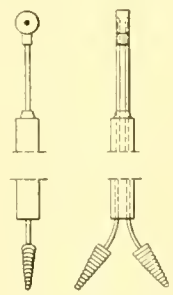


Fig. 2 Krell Apparatus for Measuring Air Velocities

vestigation and shows the amount of air flowing through the various pipes. The values given in the last line were found by comparing the average values obtained directly from air measurements in front and behind the exhauster with the total quantities of air sucked in, and the difference was distributed to the various branches in proportion to their part in the operation of the system. It is interesting to note that the quantities as actually determined by measurement differ but little from those calculated. The measurement indicates at some places velocities too low for the proper operation of the plant. This is, however, of no practical importance since, when the plant is actually operated, the branches do not all work at the same time, as was done during the test,

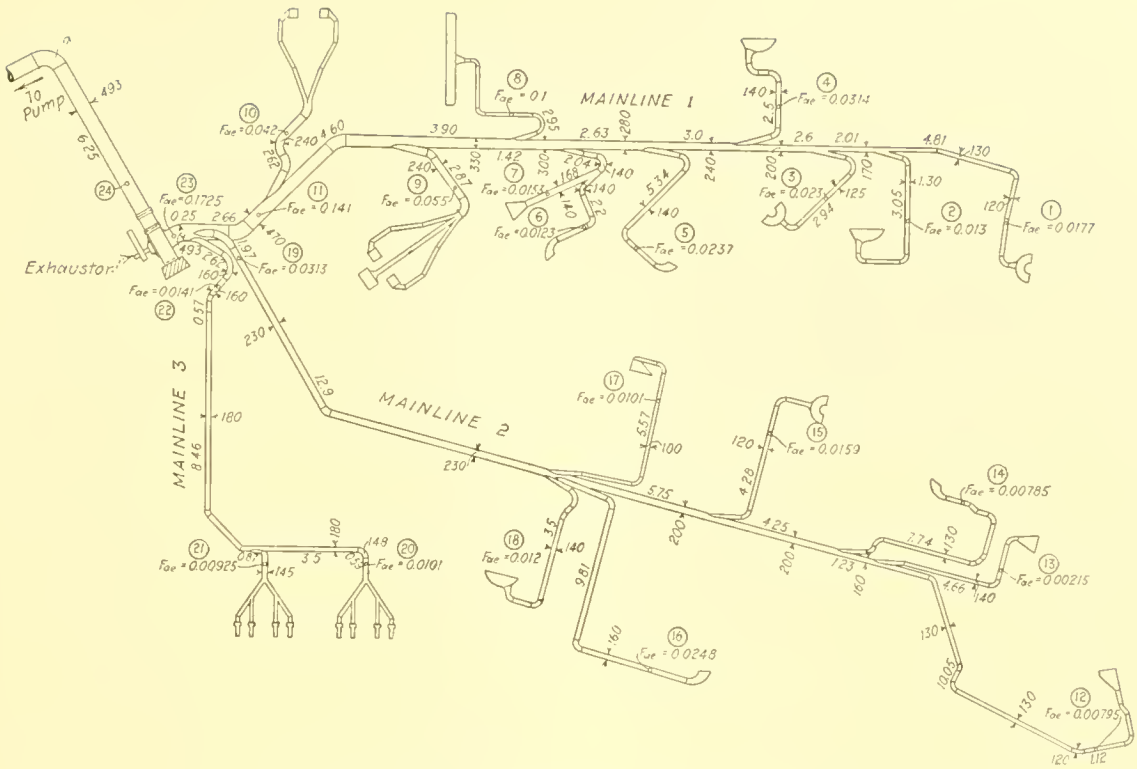


Fig. 3 Branched Piping for an Air Suction System, Piping Plan

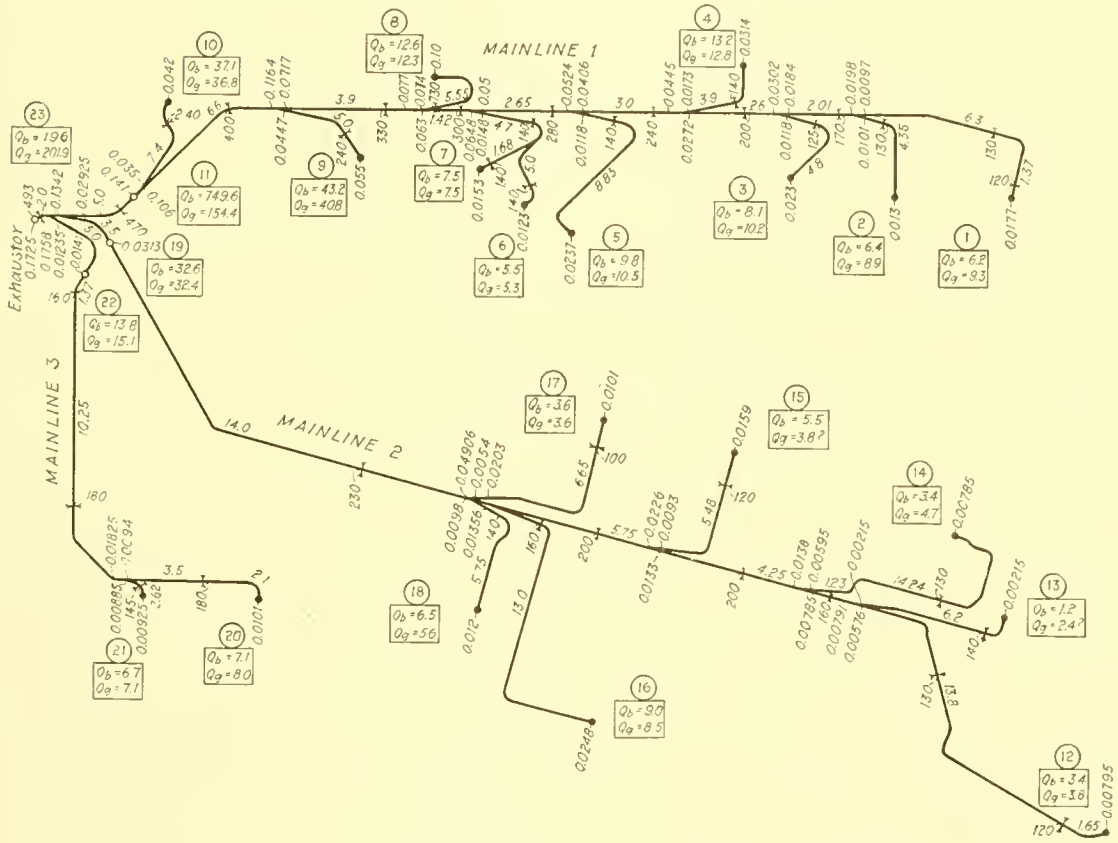


Fig. 4 Same System as in Fig. 3, with the Indication of equivalent lengths of pipes

TABLE 1 BRANCHED EXHAUSTOR SYSTEM

Point of Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Diameter D ....mm.	130	130	125	140	140	140	140	130	240	240	470	130	140	130	120	160	100	140	230	148	145	160	495	498
Diameter D ....in.	5.2	5.2	5.0	5.6	5.6	5.6	5.6	5.2	9.55	9.55	18.8	5.2	5.6	5.2	4.8	6.1	4.0	5.6	9.2	5.91	5.65	6.4	19.7	19.95
Manometer (velocity measurement) ....mm. water	127.4	114.8	181.4	176.8	121.4	30.0	60.2	218.8	208.6	169.6	210.0	24.0	7.2	1.49	1.31	2.1	2.55	1.58	6.47	2.38	2.8	5.98	12.2	11.8
H_{at} measured ....mm. water	13.14	11.83	18.7	18.2	12.5	3.09	6.2	22.55	21.5	17.5	21.6	2.47	0.74	3.89	3.45	5.4	6.6	4.07	16.5	6.17	5.35	15.4	31.5	30.2
Average velocity $v=3.17\sqrt{H_{at}}$ ....m./sec.	11.5	10.9	13.7	13.5	11.2	5.6	7.9	15.05	14.7	13.25	14.7	5.0	2.73	6.25	5.9	7.4	8.15	6.1	12.9	7.9	7.3	12.4	17.8	17.4
Average Velocity $v=3.17\sqrt{H_{at}}$ ..ft. per sec.	37.8	35.8	45.0	44.2	36.8	18.4	26.0	49.5	48.2	43.5	48.2	16.4	9.0	20.5	19.4	24.2	26.7	21.0	42.3	26.0	24.0	40.7	58.5	57.1
$Q=60\frac{\pi}{4}D^2v$ ....cbm./min.	9.1	8.7	10.0	12.5	10.3	5.2	7.3	12.0	39.9	36.0	153.0	4.0	2.5	5.0	4.0	8.9	3.8	5.9	32.1	8.1	7.2	15.0	204.0	203
Calculated volume of air Q_g ....cbm./min.	9.3	8.9	10.2	12.8	10.5	5.3	7.5	12.3	40.8	36.8	151.4	3.8	2.4	4.7	3.8	8.5	3.6	5.6	32.4	8.0	7.1	15.1	201.9	201.9

while it has been experimentally established that the velocity of air in the branch pipes rises materially when the suction system is only partly opened. This explains why actually the system operates in a satisfactory manner.

The investigation of this plant afforded an opportunity to test the process of Blaess for the calculations of branched piping. The fundamental idea of the Blaess process is in the use of equivalent openings and their connection in series and in parallel. By an equivalent opening of a pipe or system of piping is meant the area of such an opening, free from contraction, which at the given pressure would permit the same amount of fluid to pass as the entire system of piping. The action of the system of piping is therefore characterized by the equivalent area instead of by the pipe friction and inlet or outlet resistance. This equivalent opening in the case of a given pipe has a practically constant value for all velocities occurring in actual practice. If the piping has no inlet or outlet resistance, the equivalent opening $F\rho$ represents only friction. On the other hand, when friction is neglected, the equivalent opening of the pipe F_a is a function of only inlet and outlet resistance. For a given pipe system, these equivalent openings may be combined as shown by the following equation:

$$\frac{1}{F_{ae}^2} = \frac{1}{F\rho^2} + \frac{1}{F_a^2}$$

At the places where two or more branches come together, their equivalent openings may be added, since there can be only one common pressure. Since the branch pipings work in conjunction with various machines and are provided with catchers of very different types, of which the equivalent openings could not be theoretically determined, we have determined these equivalent openings from the following equation:

$$Q = 60F_{ae}\sqrt{H_u} \text{ and } F_{ae} = \frac{Q}{240\sqrt{H_u}}$$

Where H_u represents the total pressure, or as in this case a partial vacuum at the place of measurement; in order to determine the equivalent openings of the various catchers with the pipes in conjunction with them, it is necessary to determine by measurement the velocity head and partial vacuum. In order to obtain as exact figures as possible it is desirable to work with high pressures and wide manometer variations. To do this, the author when measuring at one pipe closed all the others, the measurements being made as before at five different points of each cross-section and the average value taken. These equivalent openings are indicated in Fig. 3.

In Fig. 4 geometrical axes of the pipes with the equivalent lengths of the various pipes are indicated, to the actual length being added certain supplementary lengths, namely: for a quarter bend of 9 deg. a length equal to 10 diameters; for bends of smaller or larger angles correspondingly smaller or larger additions. The equivalent openings are also marked.

From these figures, it appears that the equivalent opening of the entire suction piping directly in front of the exhauster is equal to 0.1725 qm. (1.845 sq. ft.) with a partial vacuum of 22.3 mm. (0.876 in.) of water. The quantity of air taken in by the exhauster is equal to

$Q_u = 60F_{ae}4\sqrt{H_u} = 196$ cbm/min. $= 6818$ cu. ft./min. which agrees fairly well with the 201.9 cbm/min. as determined by direct measurement. If it is desired to determine the quantity of air flowing through any of the branches, it is

necessary only to divide 196 cbm min. in proportion to the ratio of equivalent opening of the pipe under consideration to that of the entire system. In Fig. 4, the quantities so calculated Q_b and the quantities Q_g actually measured are indicated at the various branches of the system.

It may also be of interest to establish the distribution of the partial vacuum in this system by using the calculated quantities of air delivery and the velocities obtained thereby, and by calculating the partial losses in the various pipes from the formula:

$$Hp = \lambda \frac{l}{D} \frac{\gamma v^2}{2g}$$

The sums of all these partial pressures from the exhaust to each of the ends of the system must be equal, namely: 22.3 mm. of water. In this connection the inlet resistance indicated in Fig. 4 must not be left out of account. The author has made all these calculations which he gives in a special table and which show that the values calculated come fairly close to the expected value 22.3 mm. (0.876 in.) of water. On the whole, the calculated values agree fairly closely with those determined by actual measurement, with the exception only of branches working at very low velocities where the discrepancy may have been due to the imperfections of the water manometer.

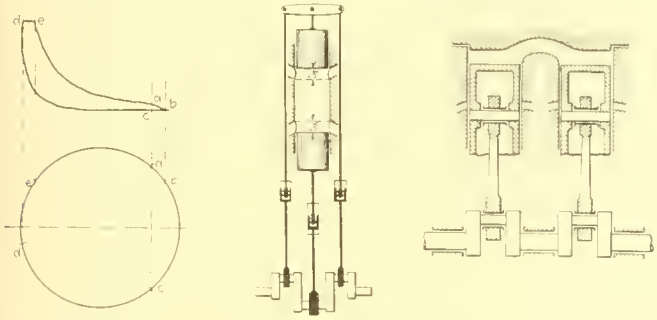


Fig. 5 Fig. 6 Fig. 7

Fig. 5 Indicator Diagram of a Two-stroke Cycle Oil Engine
Fig. 6 Diagrammatic View of a Junkers Engine
Fig. 7 Diagrammatic View of a Toussaint Engine

Hoisting Machinery

Elevators at the Stations "Abbesses" and "Lamarck" of the North-South Electric Railway in Paris (*Les ascenseurs des stations "Abbesses" et "Lamarck" du chemin de fer électrique Nord-Sud de Paris,* H. Brot. *Le Génie Civil,* vol. 44, no. 6, p. 107. 5 pp., 14 figs. *d*). At some of the stations of the North-South Electric Railway in Paris cage type elevators are used, at the Pigalle station escalators of the Hocquart type. The present article describes the former. Each station is provided with two cages running in parallel shafts. Each cage has, in addition to the usual two doors, for entrance and exit, an emergency door by means of which the two cages may be connected with one another. If for any reason, therefore, one of the cages should be stuck between floors, the passengers would not have to be kept locked in until the defect was repaired: all that is necessary is to bring up the other cage, empty, to the proper level, open the emergency doors and transfer the passengers. After a careful study, a nearly semicircular shape was adopted for the cabins because it was found that that form accommodated the largest number of passengers for the given floor space. The lifting gear consists of a drum with four screws, driven by two electric motors. The total weight of the cage with passengers being about 12 metric tons (say 13.1 short tons), it was thought advisable to lighten the stresses in the transmission from the motors to the drum by dividing the worm gear corresponding to each motor, into two symmetrical units, with gear wheels in mesh with one another but rotating in opposite directions. Owing to this arrangement there is no thrust along the motor axis, so that thrust bearings could be dispensed with. If a tooth in a gear wheel should break, the connection between the motor and the drum would not be broken. The "triple-grip" safety device is used, to protect the cage from excessive speeds.

Internal Combustion Engineering

Calculation of Length of Passages in Two-Stroke Cycle Oil Engine having Distribution by Means of Ports (*Berechnung der Kanallängen von Zweitakt-Ölmaschinen mit Schlitzsteuerung,* O Föppl. *Zeitschrift des Vereines deutscher Ingenieure,* vol. 57, no 49, p 1939, December 6, 1913. 5 pp., 8 figs. *mt*). An important point which must be considered in the design of two-cycle oil engines is the correct dimensioning of exhaust and admission slots. This matter is comparatively simple in the case of four-cycle engines where there is a full stroke available for the exhaust and another one for filling the cylinder with fresh air, but in two-cycle engines the requirements are much more strict, as at the point *a* (Fig. 5) at the end of the expansion the exhaust of gases begins. As soon as the pressure has sufficiently gone down, namely at *b*, the entrance of fresh air begins which is expected to drive the rest of the gases of combustion out of the cylinder and provide the necessary oxygen for the next combustion (the Diesel process is here considered). At *c* the charging process is considered finished and the compression of the fresh air begins, while at *d* the compression is ended, or nearly ended, and the admission of the fuel begins, continuing at constant pressure up to the point *e*. Thus the exhaust and charging processes must be fully accomplished within the brief period from *a* to *e*, which on the crank diagram represents only 90 to 120 deg. as against 360 deg. in the four-cycle engine.

Every unnecessary increase of the angle between *a* and *c* decreases the useful stroke of the engine and therefore its output and mechanical efficiency. On the other hand, if too much saving in time is attempted and the exhaust lead *a-b* is made too small, there is danger that the exhaust gases will flow back into the fresh air and pollute it; at the same time, too short a period of scavenging necessitates

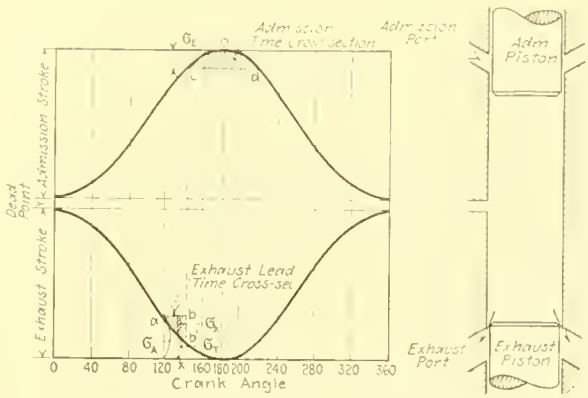


Fig. 8 Crank Path Diagram for a Junkers Oil Engine

driving the fresh air at too high a pressure which may lead to excessive consumption of power at the scavenging pumps. For example, in the early engines the scavenging took as much as 15 per cent. of the indicated power, while with proper dimensions of ports it ought to take only 3 per cent to 6 per cent.

All these considerations apply only to engines having distribution by means of ports, in particular to double-cylinder engines in which admission and exhaust are regulated by one of the pistons respectively.

Fig. 6 shows a Junkers engine of the present type with opposite pistons acting on a two-throw crankshaft. Fig. 7 shows what is called a Toussaint engine with pistons in parallel, one acting on the admission port and the other on the exhaust port.

The problem of the present investigation is to determine the processes of equalization of pressure which take place at the opening of ports. Two vessels, the cylinder and exhaust space, or the compressed air container and the cylinder, are filled with gases at different pressures, different temperatures, and having different specific gravities and for a certain time are connected by the ports. The problem is to determine quantitatively the process of equalization of pressure due to the flow of gases from the higher pressure level to the lower. This problem would have been comparatively simple if the shape and cross-section of the ports remained constant, in which case the flow of the gases during the opening would be proportional to the time-cross-section. In the present case, however, the section of the port varies from zero to maximum and back to zero again. One has therefore, to consider what happens during an infinitesimally short period dt. During dt there is available to the flow of gas a time-cross-section Fdt, while the quantity of gas or air which flows during the time period dt is

$$dG = F.\ dt.\ \gamma\ v\ f\ (p_1,\ p_2,\ T) \ldots\ldots\ldots\ldots [1]$$

where v is the coefficient of contraction, γ specific weight, and $f\ (p_1,\ p_2,\ T)$ is a function of pressure p and temperature T which, for particular cases may be determined from the theory of flow of gases. The total quantity of gas G which passes through the port during the entire period of the operation of the process of pressure equalization is therefore

$$G = \int_{t=0}^{T} F.\ dt.\ \gamma\ v.\ f\ (p_1,\ p_2,\ T) \ldots\ldots\ldots [2]$$

The members under the integral sign all vary with time. The exact determination for the exhaust and admission processes in the oil engine has been indicated by Kreglewski in his book [ep. also his articles in the *Oilmotor* (end of 1913 and in 1914)]. By the methods indicated by him and in view of the fact that there are plenty of data for the determination of the value of v, it is possible to determine the correct dimensions of the admission and exhaust ports just as Kreglewski has done for the oil engines of the German General Electric Company.

Kreglewski, however, assumes that the magnitude of the contraction coefficient v for the temperature under consideration and the shape of port is known. In the present method, the method of similarity is used, it being assumed that experiments have been made to determine the exhaust and admission processes in a certain engine and that it has been established for what speed the exhaust and admission ports have been properly dimensioned; then by the method of similarity the proper dimensions of the ports for every other engine may be determined. Two engines are of different dimensions of cylinders, length of stroke and speed. Nevertheless, when the exhaust port is opened, under the assumption of normal load, the pressure, temperature, and specific weights of the exhaust gases in both engines will be approximately equal, but owing to the flow of exhaust gases from the ports, the state and quantity of the gases in the two cylinders vary, and with very considerable approximation, we may assume that the state of the gases in the two engines varies equally, or that at points of equal pressure, equal temperatures and equal specific weights prevail in both cases. The average velocity in the exhaust passages depends on the difference of pressure in the cylinder and the exhaust tank, the temperature and the specific weights of the exhaust gases, and the coefficient of contraction, which last may be assumed to be equal in both cases. Then at the points of equal pressures and at proper instants of time may be obtained equal velocities in the passages or, which means the same thing, the quantities of gases flowing per second would be at these time-instants proportional to the free sections of the passages.

Now it is clear how the "corresponding points" in the two engines are obtained. The amounts of gases flowing out at the points of equal pressure are in the first place proportional, under the assumption above made, to the quantities of exhaust gases initially present and, on the other hand, they are proportional to the free time-cross-sections $\int Fdt$ of the passages, which means that in these points the value of $\int Fdt$ for both cylinders is proportional to the initially present quantities of exhaust gases, or approximately, to the volume of cylinder swept by piston. The admission ports should be opened (point b) as soon as the pressure of the exhaust gases has reached an appropriate value. The time-cross-section for the exhaust lead (points a to b) has therefore to be made proportional to the volume of cylinder swept by the piston V, or

$$\int F_1 dt : \int F_2 dt = V_1 : V_2 = \frac{D_1^2 s_1}{D_2^2 s_2} \ldots\ldots [3]$$

where F are the variable ports, s the strokes, V the volumes of cylinders swept by the piston, and D the diameters of the cylinders of the two engines.

Similar considerations apply to the charging process. Here it is assumed that at the beginning of the opening of the admission ports the pressures of the exhaust gases in the cylinders of both engines are equal and the conditions of the equation just preceding are therefore satisfied. The condition of equal scavenging relations in both engines takes, therefore, also the form of the preceding equation where $\int Fdt$ represents the time-cross-section for the charging port. The meaning of the integral $\int Fdt$ and the method of its determination requires some further explanation. F is the free cross-section of the port at the instant t and is equal to $\xi D \pi s_x$, if by s_x be denoted the free

distance from the regulating edge of the piston to the regulating edge of the port, and by ξ is denoted the ratio of the sum of the widths of ports to the circumference of the cylinder. The simplest way to determine the value of the integral is by means of a crank path diagram, such as is drawn in Fig. 8 for a Junkers engine. On the horizontal axis are represented the crank angles α which represent also time, since the angular velocity is constant. On the Y-axis are indicated the corresponding piston positions. In a the exhaust passages are opened by one piston; at the time x they are opened to the extent of $s_A - s_1 = s_x$, where s_A is the maximum opening of the port, and s_1 the distance of the piston from the dead point. The total time-cross-section $\int Fdt$ for the exhaust lead is represented by the area abb'; which, on account of the scale used, has to be multiplied by $\xi D\pi$. In c the regulating edge of the other piston passes the admission port. The area cod is the useful time-cross-section for the charging process, and the author shows that the two integrals which express the time-cross-sections of the two engines (in stroke-percentages times crank angles) are to one another in the same ratio as the respective products of the cylinder diameters by the speed in revolutions. The part of the stroke which has to be sacrificed for the admission and exhaust processes, increases therefore, for the same processes, with the diameter of the engine and its speed in revolutions, and, consequently, the expression $\frac{\int \sigma_x d\alpha}{D_E}$ is a constant for all engines with properly dimensioned ports, and is denoted by C_E for admission and C_A for exhaust. If the dimensions of the ports (C_E and C_A) have been determined (e.g. by tests) for one engine, the dimensions of the ports for all other engines may be derived therefrom.

Equations [7] and [9] permit the proper length of ports to be obtained for any conditions. In all practical cases, the deviations from the exact graphical determinations in accordance with equations [4] and [5] do not exceed 3 per cent and are therefore really so small as to be hardly worth considering even in the final design. Attention must be called here to certain assumptions which have to be taken into consideration in the final application of this formula. As was mentioned above, it is assumed that approximately 25 per cent more fresh air is blown into the cylinder than is actually required for compression and combustion. This excess of air is obtained by making the volume of cylinder swept by the piston of the charging pump 1.35 to 1.45 times as large as that of the corresponding working cylinder. The admission ports are then proportionally dimensioned if the average pressure in the scavenging tank at the average speed of the engine is 0.08 to 0.12 atmospheres. If in the case of any engine in which the admission ports have been calculated in accordance with equation [7], a different pressure is used in the scavenging tank, the dimensions of the passages have to be correspondingly changed in accordance with the value of the C_E for the latter case. The value of σ_A is determined by the initial pressure at the beginning of the exhaust, which is to a certain extent proportional to the average indicated pressure p_i. Since this average indicated pressure in the case of two-cycle engines varies between 6 and 10 atmospheres, the final selected value of C_A must be always brought in accord with this average indicated pressure. The pressure of the exhaust gases in the cylinder at the opening of the admission ports should, if the passages have been properly dimensioned, amount to 0.3 to 0.5 atmospheres, which is sufficient to prevent the back flow of exhaust gases into the charging air.

For example, in an engine in which the pressure of the exhaust gases at the opening of the admission ports amounted to as much as 0.8 atmospheres out of the total mass of the exhaust gases only three to four per cent have come back into the charging air as has been established by means of diagrams and analytically. Such a small amount will be most likely forced out for the most part by the excess of air, which shows that even a back pressure of 0.8 atmospheres does not cause any serious pollution of the charging air.

The author shows further how to apply this formula to the case of a single-piston engine.

Gas Cleaning According to the New Theisen Process (*Die Gasreinigung nach dem neuen Theisenschen Verfahren, Stahl und Eisen*, vol. 33, no. 51, December 18, 1913, 7pp., 12 figs. *de*). During the last few years a new type of the Theisen gas washer of the disintegrator type has been placed on the market. In several places careful tests of its efficiency have been made. At the Differdinger metallurgical plant a large Theisen disintegrator with a water separator has been installed at the end of 1912, and is at work since then continuously. This disintegrator was designed for preliminary cleaning of blast-furnace gas at the rate of 40,000 cbm. (1,412,580 cu. ft.) per hour from a dust content of 4 grams per cbm. (1.736 grains per cu. ft.) to 0.3 to 0.5 (0.1302 to 0.2170 grains per cu. ft.). As a matter of fact, however, the gas as it came from the furnace had a dust content of only 0.88 to 1.46 grams per cbm., and the output of the disintegrator as regards the purity of the gas was therefore even better than the guarantee. Several hundreds of tests have been made with this disintegrator in order to determine its best efficiency at various pressures and with various amounts of water.

The power consumption as given in Table 2 includes a comparatively high suction and pressure, and would be considerably lower with smaller pressure variations.

At the Rombach metallurgical plant in Rombach two Theisen disintegrators with an output of 30,000 cbm. (1,059,430 cu. ft.) per hour have been at work, one continuously for 14 months. Not long ago careful tests of output were also made there and the results are given in Table 3. In Rombach the output has been measured by three different methods, first by a hydro apparatus specially calibrated for this purpose; next by a Rabe tube, and finally by means of a gasometer of 4000 cbm. (141,258 cu. ft.) capacity and 80 mm. (3.14 in.) of water pressure. The fact that the pressure of disintegrator 2 is less than that in disintegrator 1 is explained by the presence in the former of a washing surface built concentrically around the pressure fan for experimental purposes. The higher power consumption (about 10 h.p.) in disintegrator 2 is due partly to greater amounts of water and also to the presence of the above-mentioned washing surface, which may be considered partly recovered in the way of greater cleanness of the gas. The temperatures show that with nearly equal

TABLE 2 TESTS OF A THEISEN DISINTEGRATOR IN DIFFERDINGEN

Gas Volume, referred to 50 Deg. Cent. (122 Deg. Fahr.), cbm per hr	Gas Pressure: In Suction Line in Front of Washer, mm of Water	Gas Pressure: Between Water Separator and Washer, mm of Water	Pressure Rise, mm of Water	Dust Content in Gas, g/cbm: In Front of Washer	Dust Content in Gas, g/cbm: After Passing Washer	Gas Temperature, Deg. Cent./Fahr.: In Front of Washer	Gas Temperature, Deg. Cent./Fahr.: After Passing Washer	Temperature of Water, Deg. Cent./Deg. Fahr.: In Front of Washer	Temperature of Water, Deg. Cent./Deg. Fahr.: Behind Washer	Water Consumption, l/cbm and gal/cu. ft.	Total Power Consumption, h.p. per 1000 cbm/cu. ft.
44327/1,571,712	−70.5	130.3	200.8	1.08	0.020	40.0/104	40.5/104.9	30/86	39.3/102.8	0.684/0.00513	5.55/0.157
47353/1,672,245	−90	150	240	1.0	0.012	32.5/90.5	33.5/92.3	29/84.2	33/91.4	0.555/0.00416	5.43/0.154
48515/1,716,460	−85	153	238	0.944	0.018	33.3/92	34.5/94.1	29.5/85.1	33.8/92.8	0.550/0.00412	5.22/0.148
46611/1,649,539	−85	158.3	243.3	0.880	0.008	32.5/90.5	33.5/92.3	29/84.2	33/91.4	0.430/0.00322	5.00/0.142

TABLE 3 DATA OF TESTS OF A THEISEN DISINTEGRATOR AT ROMBACH

(Arrangement of Data same as in Table 2)

30252*/1,068,963	−30.0	196.5	226.5	0.22	0.014	29/84.2	31/87.8	27.0/80.6	30.4/86.7	0.549/0.00411	4.1/0.116
40312*/1,074,261	−22.9	137.1	160.0	0.35	0.016	30.6/87	31.3/88.3	26.4/79.6	30.8/87.4	0.699/0.00524	4.5/0.127
33050*/1,520,288	−55.0	130.0	180.0	....	....	....	....	....	....	0.387/0.00290	2.9/0.082

* Referred to 20 deg. cent. (68 deg. fahr. and 760 mm pressure)

entrance temperature of the gas and water there is a slight rise of the heat in the water and the gas, originated partly by conversion of work in the washer into heat.

Another disintegrator of the countercurrent type is now at work in an Austrian metallurgical plant. There a very interesting comparison was made between a Theisen disintegrator and a disintegrator of the Schwartz-Bayer system. Both cleaners take the raw gas from a common pipe and send the cleaned gas into a common pipe again. The dust content of the raws gas, the pressure of the latter, and the pressure in the cleaned gas piping are therefore equal for both apparatus. The output and power consumption in both apparatus are also practically equal, while the water consumption and the degree of cleanness are shown by Table 4. These experiments tend to show that the Theisen disintegrator under equal conditions of operation as compared with the Schwartz-Bayer disintegrator works with about one-half water consumption and about ten times higher degree of cleanness. As regards space requirements and reliability of operation, the Theisen disintegrator is also materially better than the other type, since it requires only a direct coupled 125-h.p. motor, while the other type requires two motors of 35 h.p. each for the disintegrator and another motor of 60 h.p. for a separately driven fan.

Artificial Rubber from Coke Oven Gas (*Le caoutchouc artificiel extrait des gaz de four à coke,* in *Economies réalisables dans l'Est et le Nord de la France par l'utilisation des gaz des fours à coke et des hauts fourneaux,* A. Gouvy. *Société industrielle de l'Est,* no. 114, p. 45, November 1913. 54 pp., 19 figs. *d*). In an article describing various applications of coke oven and blast furnace gas, and apparatus for utilizing them, the author mentions also a German patent obtained by the Tar Utilization Company (Teerverwertungsgesellschaft) of Duisburg, Germany, for producing artificial rubber from coke oven gas. The processes of Bayer and others are based on the manufacture of a hydrocarbon called butadene, and converting it into isoprene, from which rubber is developed. The new process is based on the fact that in coke oven gas there is already a certain amount of butadene present; benzole is submitted to fractional distillation, of which the products are then kept for a certain length of time in contact with sodium; the latter causes the precipitation of the sodium compounds, and the subsequent polymerization of the other hydrocarbons, which may be intensified by the presence of small quantities of ammonia. The rubber obtained is said to be good, but the cost of the process is yet high.

TABLE 4 COMPARATIVE TESTS OF A THEISEN AND A SCHWARZ-BAYER DISINTEGRATOR

	Water Consumption, g/cbm	Cleanness of Gas, g/cbm
Theisen disintegrator	0.7—0.9	0.03—0.06
Schwarz-Bayer disintegrator	1.3—1.5	0.3—0.5

The author attempts to estimate the value of the blast furnace and coke oven gas obtained in Eastern and Northern France, where 4,480,000 tons (metric) of pig iron are produced. This corresponds to an output of coke of 4,480,000 metric tons per year, or 511.3 tons per hour, which, at the rate of 4500 cu. m. of gas per ton of coke, gives (after the deduction of 40 per cent for the Cowper blast heater and 10 per cent of what remains for the blower) 1,242,459 cu. m. per hour. This, at 0.04 franc ($0.008) per kw-hr. and 5000 hours per year, corresponds to an output representing 53,300,000 francs ($10,697,000) per year. This leaves 3760 hours in which the gas is supposed not to be utilized for power purposes, but might be so utilized for by-product manufacture, e.g., the production of nitrates or nitric acid. A similar calculation is made for the coke furnaces. With a demand for approximately 510 tons per hour of coke, and a coking efficiency of about 75 per cent, 680 tons of coal have to be treated per hour, with a pro-

duction of gases 190,400 cu. m. One half of this output of gas will be consumed by the furnaces themselves, while the other half corresponds to 104,000 kw., which, for 5000 hours of operation per year, are worth 20,800,000 francs ($3,952,000). There remains still the output of 3760 hours, which may be used either for chemical manufactures or for lighting, the gas in either case having a value of approximately 0.03 franc ($0.006) per cu. m., or for the whole, 10,738,260 francs (say $2,033,000). In addition to that, the coke ovens may be rebuilt in such a manner as to permit burning in them the comparatively poor blast furnace gases (e.g., during the time when the demand for power is insufficient to take care of the entire output of blast furnace gases). To an input of 5 cu. m. of blast furnace gas corresponds an output of 1 cu. m. of coke oven gas, and as there are about a quarter million of cu. m. of blast furnace gas available per hour during the 3760 hours per year when the demand for power is low, and as a cu. m. of coke oven gas may be taken to be worth 0.03 franc ($0.006), the increased coke oven gas production means an additional source of profit of 28,026,600 francs ($5,320,000). The by-products of coke oven manufacture represent a further sum of 2.50 francs (0.48), the total gain from the utilization of blast furnace and coke oven gases on a production of only 4,480,000 tons per year being as follows:

	Millions of Fr.	Dollars
Motive power from blast furnace gases, 5000 hours per year, at fr. 0 04 per kw-hr. . .	56 3	10 697
Motive power from coke oven gas, same assumptions as above..	20 8	3 952
Coke oven gas used for chemical manufactures or lighting (fr. 0 03 per cu. m.)	10 7	2 033
Extra coke oven gas produced by the use of blast furnace gas in time of low demand for power.	28 0	5 320
By-products of coke manufacture..	14 9	2 831
Total.	130 7	23 833

Investigation Concerning Heat Engine Operation (*Enquête sur le fonctionnement des machines thermiques*, *La Technique moderne*, vol. 7, no. 11, p. 369, December 1, 1913. 6 pp., 9 figs. *d*). *La Technique Moderne*, an important French engineering paper, has determined to start an inquiry as to accidents and difficulties connected with the use of high thermal efficiency prime movers, such as engines and turbines working with highly superheated steam, "poor" gas engines and gas producers, liquid fuel engines, either of the explosion or the Diesel type. The following points will be investigated; (*a*) causes of wear and deterioration of turbine blades; (*b*) difficulties encountered in the application of high superheats in reciprocating steam engines; (*c*) causes of rupture of air pump beams and shafts in reciprocating air pumps; (*d*) causes of rupture of bolts in the connecting rod head of single acting gas engines and causes of ruptures in internal-combustion engines generally; (*e*) causes of explosions in the casing, pipes, etc., of internal-combustion engine plants, etc.

The leading idea of the investigation appears to be that many accidents and troubles remain unexplained, and factory owners often hesitate in adopting a new type of engine, notwithstanding the economy that might be obtained by making the change, through fear of installing too complicated and delicate apparatus. This brief program of the inquiry is followed by an article by Professor Letombe, of a general character, on various types of heat engines.

New Projects and Experiments in the Gas Turbine Field (*Neuere Vorschläge und Versuche über Gasturbinen*, Schultz. *Der Motorwagen*, vol. 16, no. 33, p 833, November 30, 1913. 5 pp., 8 figs. *dg*). A review of the compressors proposed within the last few years for use in connection with gas turbines, such as the Puttler blower, the Brown-Boveri blower (works by means of an oscillating mass of water acting as a piston, somewhat like the Humphrey pump), the Lehne compressor, the Armengaud-Lemale system, etc. As regards the materials to be used in gas turbine construction, the most serious problems arise in connection with the construction of turbine wheels and blades, which are subjected to high stresses at the same time as to high temperatures. This is similar to what the steam turbine engineer has to deal with, with the difference, however, that the gas turbine material must also stand the chemical action of some of the constituents of the gases, e.g., hydrogen sulphate and sulphurous acid. The tests of Jahn have shown that the alloy which stood very well the chemical action of these gases at 420 to 436 deg. cent. (788 to 816.8 deg. fahr.) consisted of approximately 52.5 per cent copper, 22 per cent cobalt and 25.5 per cent zinc, while the action of wet sulphurous acid was best resisted by an alloy of 52.2 per cent copper, 30.4 per cent cobalt and 17.4 per cent zinc.

Tests of a New Peat Suction Gas Installation (*Versuche mit einer neuen Torf-Sauggasinstallation*, H. *Glasers Annalen für Gewerbe und Bauwesen*, vol. 73, no. 875/11, p. 208, December 1, 1913. 2 pp., 7 figs. *de*). The tests were made with peat suction gas engines and generators of German manufacture, the engine driving a dynamo (90 kw. at 740 r.p.m.) supplying current for the various requirements of the factory where the tests were made. The power output varied within wide limits and suddenly, jumping from normal load to one third of it, then to 68 kw., from which it fell to no-load, only to change back to 68 kw. Notwithstanding all these changes, the composition of the gas did not vary to any very serious extent. As regards fuel consumption the following data are quoted. The power delivered by the dynamo as indicated by the wattmeter was, for a 6-hour run, 420.5 kw-hr., to which corresponded a fuel consumption of 929.1 kg. (2044 lb.) of imperfectly dried peat, or 2.21 kg. (4.86 lb.) per kw-hr. (repeated control tests have given less satisfactory results). The current consumption for the fan drive took 5.3 kw., or about 7.5 per cent of the total power developed. In installations of more permanent type the fan ought not to take more than 6 per cent, in which case the total fuel consumption would amount to (100 : 94). 2.21 kg. = 2.35 kg. = 5.17 lb. per kw-hr. The peat was rather poorly dried (59.28 per cent of moisture).

Thermal and Mechanical Methods of Shop Treatment of Metals. Case Hardening (*Traitments thermiques et mécaniques des métaux a l'atelier. Cémentation*, F. Robin. *Revue de mécanique*, vol. 33, no. 5, p. 409, November 30, 1913. 50 pp., 24 figs. *gp*. The second part of the abstract will appear in a future issue.) Two kinds of case carburization may be distinguished: complete carburization of metals or core carburization; and case carburization or case hardening of metal parts which must support considerable penetration stresses and at the same time must preserve as much of their malleability as possible.

The author discusses the various theories of case carburization and comes to the conclusion that carburizing action must be ascribed practically exclusively to carboniferous gases, namely, to carbon monoxide. In this connection it becomes important to consider the value of gases given off by various kinds of carburizers in use, especially in view of the fact that an excessive evolution of such gases may cause explosions during carbonization. De Nolly and Veyret have studied this problem and recommend the following precautions: (*a*) To avoid animal and vegetable matter giving off too much gas at low temperatures. (*b*) To use with barium carbonate (30 to 50 per cent) only charcoal carbonized at a very high temperature. The evolution of gas is thus smaller and the percentage of hydrogen lower. (*c*) To heat the mass slowly up to 700 deg. cent. (1292 deg. fahr); the air can then escape and the violent evolution of gases at a temperature around 700 deg. cent. is reduced.

As regards possible weakness of the core of the carbonized part, nitrogen is only occasionally the cause, but hydrogen is far more dangerous in that it produces hard or brittle places consisting of pure ferrite.

The evolution of gases with different kinds of carburizers in use occurs approximately in the following manner: Pure charcoal at temperatures from 0 to 300 deg. cent. (32 to 572 deg. fahr.) evolves gases which are absorbed by the charcoal itself. At 300 deg. cent. (572 deg. fahr.) there is a minimum of gas generation. The air is driven off and the volatile gases are still occluded. From 300 deg. to 700 deg. cent. (572 to 1292 deg. fahr.) the internal evolution of the gases takes place, and at 700 deg. cent. there is a maximum of evolution equal to about 30 times the volume of the charcoal. Beyond that temperature the evolution of the gases decreases. At 1100 deg. cent. (2012 deg. fahr.) the contents of carbon monoxide increases a little. At the second heating the evolution of gas is very weak. The mixture of barium carbonate and charcoal calcined at 1000 deg. cent. (1832 deg. fahr.) gives off practically no gases until 600 deg. cent. (1112 deg. fahr.), the evolution of the gases reaching its maximum toward 1000 deg. cent. At 1050 deg. cent. (1922 deg. fahr.) the gas contains 75 per cent carbon monoxide and 12 per cent hydrogen. Ferro-cyanide carburizers reach their maximum of evolution of gas at about 800 deg. cent. (1472 deg. fahr.), but very rapidly cease to give off gas.

Case carbonization is therefore the result of the absorbtion by iron of the carbon left in the carburizing material by the evolution of the gases, but in order that iron might absorb carbon, it must be in the allotropic state γ, since iron in the state α does not dissolve carbon, at least not constantly and in a useful manner. By heating iron in close contact with the carburizer above 700 deg. cent. (1292 deg. fahr.), or even up to 560 deg. cent. (1040 deg. fahr.) the beginning of carburization is obtained. Giolitti and Carnevali have shown that steel with very low content of carbon is not carburized at all below 780 deg. cent. (1436 deg. fahr.), and they explain facts to the contrary mentioned above by supposing that carbon monoxide easily penetrates into iron at the temperature around 500 deg. cent. (932 deg. fahr.) and by decomposition deposits there carbon which is not really dissolved in the iron. Charpy appears, however, to have produced under these conditions superficial cementite which tends to show a certain solubility of carbon. However, industrial case carbonization of iron does not begin until about 850 deg. cent. (1562 deg. fahr.). Steel subjected to case carbonization often has an initial content of carbon of 0.3 per cent. not counting manganese, silicon and other elements. The point of transformation in such cases easily reaches 780 deg. cent. (1436 deg. fahr.), and the carburization once started, the piece of steel is rapidly covered by a thin layer of iron more or less saturated with carbon of which the normal temperature of transformation is only 700 deg. cent. (1292 deg. fahr.). Between this external layer and the core of the metal piece there are formed other layers of a transitional nature with regard to the point of transformation which gradually rises as the layer is deeper inwards. The diffusion of these layers from one to the other occurs the more rapidly the higher is the temperature used, but is very slow and more often ceases altogether at a certain point if the temperature is below the temperature of transformation in that region, hence the too sudden transition in the composition of the piece which may be harmful to the strength of the case carbonized layer. The pieces when case carbonized ought, therefore, to be heated at least up to 850 deg. cent. (1562 deg. fahr.). For the investigation of the results of the case carbonizing operation two methods may be used—chemical analysis and microscopic investigation.

For the chemical analysis, very thin shavings from the surface of the metal might be taken by a milling machine and analyzed, thus showing the distribution of the carbon throughout the depth of the piece. This process is very useful in scientific investigations, but cannot be conveniently applied in the shop where microscopic investigations are preferable. The microscope shows the thickness of the carburized layer with its variations in the content of carbon and the physical structure of the core, the transitionary layers and the periphery on which depends the cohesion of the various regions and the brittleness of the whole piece, but the microscope does not indicate the sulphur contents and the presence of occluded gases—factors of great importance for determining the quality of the final product.

The author shows by figures how various iron-carbon compounds look under the microscope.

Thickness of carbonization should be not more than one-third of the depth of the piece carbonized, since otherwise rupture through excessive brittleness of the periphery may be produced. If the piece is case hardened only on one side, however, it is said that the carbonization may go as far as one-half of the depth. In cases where the carbonized piece is subject to shocks, it is necessary that the depth should be less than when it is subject only to static stresses.

As regards the selection of carbonizing materials, the following general conditions may be stated: (*a*) The carburizer ought to have as high a velocity of carburization as possible, since the longer the operation lasts the more expensive it is and the more chance there is for the metal to change its properties. It is also better to work at as low a temperature as possible. (*b*) The carburizer must not contain sulphurous matter, as the metal absorbs it and becomes hot short. At most there may be up to 2 per cent of sulphur at a temperature between 900 and 950 deg. cent. (1652 to 1742 deg. fahr.). At between 950 and 1000 deg. cent. (1742 and 1832 deg. fahr.) the sulphur volatilizes. At the surface 0.88 per cent of sulphur has been found. (*c*) The carburizer must be as good a conductor of heat as possible. This is important in order to minimize the errors

due to the difference of temperature of the furnace and the pieces carbonized, each of the latter being heated in the powder in order to avoid the inconvenience of too long cooling. (*d*) It must have as low specific heat as possible. This property is necessary for the same reason as the preceding one. It is always well to heat up the box as quickly as possible, in order to avoid substantial errors with respect to the time of heating and its temperature, as well as to eliminate useless heating losses. (*e*) The carburizer must not alter the surface of the piece. Scratches, erosions, etc., require expensive machining and are harmful to pieces where precise dimensions have to be maintained. (*f*) Where brittleness must be avoided at all costs, it is necessary to adopt other conditions, often less compatible with the preceding ones, namely: (*a*)*Progressive* penetration of the carbon into the iron; a carburizer which acts too suddenly and roughly produces often hyperentectoid layers. When precision in the operation is required with the formation of the thin but hard layer, the composition and action of the carburizer have to be very exact. (*b*) In addition to that, a good carburizing powder has to satisfy the following conditions: (*a*) it must contain materials which can be easily powdered in order to give a uniform and close mixture; (*b*) it must not exhaust rapidly; good case carburizers can be used many times with great economy and regularity of results. (*c*) It must *not* be expensive; must be free of danger of explosions; and must not produce dust excessive in quantity or dangerous in action. (*d*) It must not decrease in volume while in the carburizing boxes, since the heaping up of the carburizer would become unequal and some pieces undergoing case hardening might be left bare. Hence the necessity to avoid too fluid or volatile elements in the composition adopted.

The author discusses in detail the use of various carburizers—solid, liquid and gaseous. Among solid carburizers the best known are mixtures of carbon and salts, the carbon used being for the most part charcoal powder, the best being poplar charcoal which gives charcoal practically free from sulphurous matter. A mixture very widely used is that of charcoal and barium carbonate, the proportions generally adopted being 60 per cent of carbon and 40 per cent of barium carbonate. This mixture acts mainly through the evolution of carbon monoxide. Whether the presence of nitrogen is absolutely necessary for the carburization or not has not been fully established. Barium carbonate is selected for its high temperature of dissociation. Calcium carbonate substituted instead of it gives an evolution of gas at considerably lower temperature, but the proportion of anhydride carbonate is much larger, which is not favorable to good carbonization.

The author shows by a diagram the depth of penetration with the mixture of charcoal and barium carbonate for various temperatures and lengths of carbonization, prepared in accordance with the experiments of L. Guillet.

With a mixture of charcoal, barium carbonate and ferro-cyanide, the admission of potassium ferro-cyanide appears to heighten the activity of the carburization process and to increase the hypereutectoid layer at the temperatures of industrial case hardening. An interesting point to remember is that powder which has been used several times is still very good and often even better the second time than it was the first time, probably owing to the loss of moisture; no iron is found in the state of free ferro-cyanide when the heating took place at the high temperature.

Mixtures of other salts have been tried with charcoal, giving practically analogous results to the use of the mixture of charcoal and barium carbonate, but the carbonizing power of the material used would become exhausted much more rapidly. A mixture of charcoal and sodium chloride (10 per cent of the latter) gives a good carbonizer and possesses regenerative power, is very cheap and can be used for case hardening to a depth of 1 mm. (or .04 in.). It is, however, too long to heat. A French investigator, Grenet, mentions the following carburizers for use in shops. They are arranged in the order of speed of carburization and price:

(*a*) A mixture of sawdust with forge coal containing 30 per cent of volatile matter. (*b*) A mixture of pulverized charcoal, 1 kg. with 1½ kg. of sawdust and 0.1 kg. of sodium chloride. (*c*) A mixture of 0.5 kg. forge coal containing 30 per cent of volatile matter, 0.5 kg. of carbonized leather, 0.1 kg. of sea-salt and 0.5 kg. of sawdust. (*d*) A mixture of 1 kg. of carbonized leather, 1 kg. of sawdust and 0.2 kg. of ferro-cyanide. According to the patents of Lamargese, charcoal from certain definite woods, and especially from resinous woods, alone or with an addition of silicon, gives excessive hardness. Coke impregnated by residues from petroleum distillation is an active carburizing material, but it is of irregular composition, which causes different results in different operations. A mixture of charcoal and concentrated solution of potassium-cyanide or charcoal and ferro-cyanide has been patented as a means of obtaining rapid case hardening admitting good practical control of results. It appears also that the view that the addition of cyanide of nickel or potassium bichromate to the carburizing material produces penetration of nickel or chrome into iron, is incorrect.

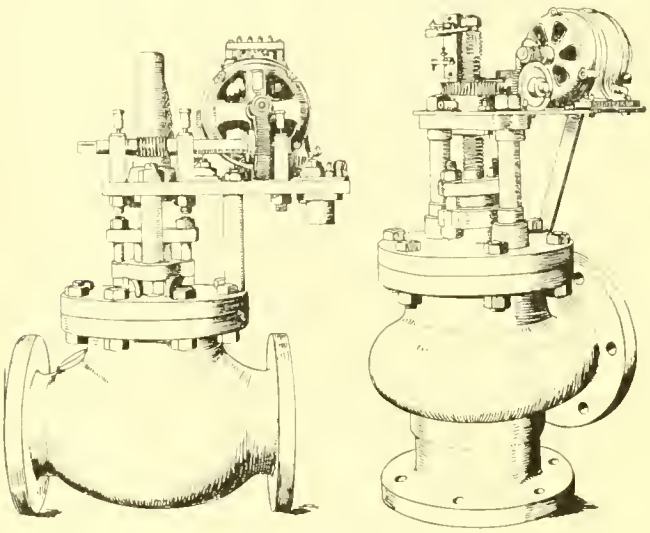
In all the experiments which the author has made at the high temperature around 1000 deg. cent. (1832 deg. fahr.), the most intense case carburization appears to have been produced by a mixture of charcoal with 40 per cent of barium carbonate. The most violent carbonization with the largest hypereutectoid layer at all has been obtained by the use of carbon alone. There may be an infinite number of formulas by the use of which good results may be obtained as long as these formulas do not depart from the general rule: carbon, or products evolving carbon, added to little volatile salts, preferably carbonates or cyanides, which act as generators of gases with the carbon base, these salts being in a powder in a quantity equal to that of the carbon. The author only cautions against the use of toxic products or products giving off poisonous gases, as well as nitrogenous products which in mixture with the carbon may produce explosions. Saltpeter in particular must be used only with the greatest care, since otherwise a mixture approaching the composition of black powder may be produced. A mixture of 60 per cent of saltpeter, 29 per cent of prussiate and 9 per cent of colophonium gives also a rapidly acting explosive.

A New Optical Pyrometer: The Radium Pyrometer, and a Gas Heated, Absolutely Black Body (*Ein neues optisches Pyrometer: das Radium-Pyrometer, und ein mit Gas beheizter, absolut schwarzer Körper,* W. Allner. *Journal für Gasbeleuchtung,* vol. 56, no. 47, p. 1145. 5 pp., 7 figs. *d*). A brief discussion of the theory of optical pyrometers followed by a description of a new type invented by the author. The radium pyrometer uses for the light stand-

and not an electric light, but a special radio-active product, and the measurement is made not in the red line of the hydrogen, $\lambda = 0.6563\mu$, but in the green radium line of $\lambda = 0.535\mu$. The radium pyrometer is not as accurate as either the Wanner or the Holborn and Kurlbaum pyrometers, since the radium light decreases at the rate of approximately 1.4 per cent per month, or 20 per cent per year.

Steam Engineering

Electrically Operated Valves and Their Application (*Elektrisch angetriebene Ventile und ihre Verwendung*, E. Claassen. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 49, p. 1946, December 6, 1913. 5 pp., 15 figs. *d*). The gate valve has a great advantage over the slide valve in that it is materially cheaper to build and therefore in small and middle sized plants it will probably be used for a long time to come. It becomes therefore of importance to provide means for its improvement, and especially for ways to close and open at a distance. One of the most convenient methods of doing it is by electric operating attachment. One of the devices for electrically operating large valves is shown in Fig. 10, providing both for an electric



Figs. 9 and 10 Combination Hand and Electrically Operated Valve

and hand operation. The motor is so installed that it does not take much space. The high speed of rotation of the motor is reduced by means of a worm drive, and at the highest and lowest positions of the valve come the current is automatically cut out. These valves can be connected with manometers and special switching devices; for example, if in the low pressure piping a contact manometer is included and set at 6 atmospheres, contacts are provided for 6.1, 6.05, 6, 5.95 and 5.9 atmospheres. If the pressure goes down from 6.1 to 6 atmospheres, the valve by the action of the current is opened one-quarter of its stroke and is closed automatically again when the pressure rises to 6.1 atmospheres. When too much steam is drawn off and the valve must be opened still more, it will open one-half stroke at a steam pressure of 5.95 atmospheres and will open fully at 5.9 atmospheres.

In the same manner as the pressure reducing device, the electrically operating valve may be used also as a safety valve in case of the rupture of the pipe, Fig. 11. Here also a contact manometer is used. As soon as the pressure in the pipe falls off owing to the rupture of the pipe, the indicator of the manometer closes the current. The valve is immediately closed and remains closed until the pressure in the piping rises to its initial value.

In large water pipe systems a float device with contacts may be used in a similar manner instead of a manometer either with or without an alarm device. The electrically operated valve may be also applied where a mixture of hot and cold water has to be maintained at a certain temperature. In this case a receiver thermometer, Fig. 12, is in-

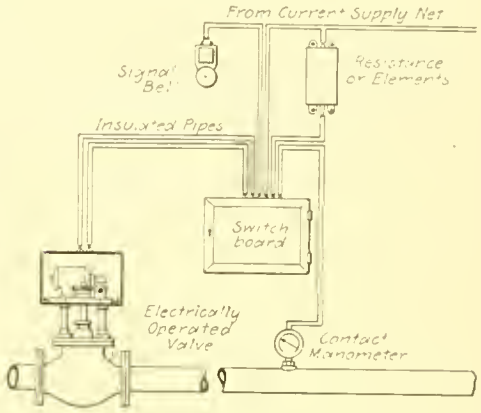


Fig. 11 Valve with Signalling Attachment and Electrically Operated Device for Automatically Closing in Case of Rupture of Pipe (for Steam and Gas Piping)

stalled with a number of contacts to which correspond a similar number of contacts on the switchboard, the thermometer closing and opening the current at the contacts and thus producing respective variations in the position of the valve.

In the same manner may be regulated the temperatures of steam and water heating systems or ventilator systems. One of the peculiarities of this system is that it can be used only with high tension current. This makes no difficulty in water pipe systems where electric power is generally used all the time, but in small steam plants its dependence on high tension current is a disadvantage. Where high tension current is not available, valves operated by electromotors at a distance cannot be used. The problem of operating valves at a distance in such cases has been solved in various places in different ways.

Thus in Moscow, where electric current is not always available for the use of the water supply system, special arrangements had to be made to close the water supply in houses in districts where a fire occurred, since otherwise the pressure available would not be sufficient for the operation of the fire engines. This was done by means of the Simin valve, Fig. 13. In case of a fire, the water supply station sends a pressure surge into the piping, and by this means all the valves in the private houses are closed.

In the Singer Sewing Machine Company's plant at Podolsk in Russia, an electrically operated valve is used, but instead of an electro-motor the lever of the valve is operated by a system of electro-magnets, Fig. 14. The magnets, *a*, are excited by wet batteries, which may be switched in at any place desired, the magnets then attracting a common armature, *b*, which liberates the tip *c* of an intermediate piece. The lever of the pipe isolating valve presses against *d*, and

by its own weight as well as by the water pressure against the pipe isolating valve *d*, is turned outwards, but as soon as the lever of the pipe isolating valve falls down, the spring *e* draws *d* back into its old position.

An improved type of the same kind of valve manufactured by a German concern is also described in detail.

TECHNICAL AND ECONOMIC EXPERIENCES IN STEAM TURBINE OPERATION (*Technische und wirtschaftliche Erfahrungen im Dampfturbinenbetrieb*, Professor Josse and K. Hoefer. *Zeitschrift für das gesamte Turbinenwesen*, vol.

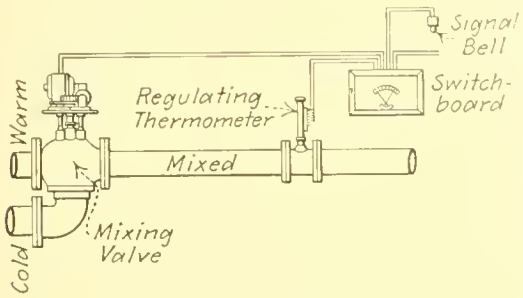


FIG. 12 ELECTRICALLY OPERATED MIXING VALVE

10, no. 33 and following, serial article, not finished. s.l. An abstract of the rest of the article will appear in an early issue). At the end of 1912 Professor Josse sent out a circular letter to a large number of electric power plants equipped with steam turbines for the purpose of obtaining a general view of the experiences gained during the last few years in steam turbine operation from a technical and economic point of view. About 130 such letters were sent out, and approximately 50 per cent answered, which gives a fairly good view of the situation as it is in Germany. The data of this investigation were worked out later on by K. Hoefer.

All the turbines have been divided into two main classes: average size, from 250 to 1000 kw., and large turbines with the useful output in excess of 1000 kw. Further, a distinction has been made between the following five classes: (*a*) pure reaction turbines; (*b*) reaction turbines with a high pressure impulse wheel such as the Curtis wheel; (*c*) pure impulse turbines such as the Zoelly; (*d*) impulse turbines with a high pressure Curtis wheel; and (*e*) impulse turbines with Curtis wheels only.

This investigation shows that for turbines of average output the pure Curtis system prevails, while the reaction turbine is mainly used in large sizes. The selection of the turbine type is, of course, governed not only by technical, but also by commercial considerations; but it must be borne in mind that the introduction of the impulse and Curtis types have begun later. Still it appears that the reaction system is more adaptable to large than to small sizes.

The investigation has confirmed the fact which has been generally known before, namely, that the sizes of turbines have a tendency towards rapid increase. The difference in the rate of increase for various types of turbines cannot, however, be established. As regards the introduction of turbines, there was a noticeable falling off in the year 1910, due probably to the economic disturbances of 1908; but in the last two or three years there was again a rapid move upwards. In 1912 only there have been installed new turbines with a total capacity of approximately 115,000 kw. and average power of 4250 kw. per unit.

The speed of rotation in the case of drum turbines and polyphase generators is usually 3000 r.p.m. for outputs of 1000 kw.; for larger outputs up to about 4000 kw. the speed is usually about 1500 r.p.m., and goes down to 880 r.p.m. for a still higher output. In disc turbines driving polyphase generators this speed varies from 3000 r.p.m. for outputs up to 2000 kw. to about 1500 r.p.m. in the case of larger outputs. With turbines driving direct-current generators, which is done only in the case of smaller units, the speed used is usually lower, owing to commutation troubles at higher speeds. The turbines work without exception with superheated steam at about 300 deg. cent. (572 deg. fahr.) and pressures up to 12 atmospheres gage

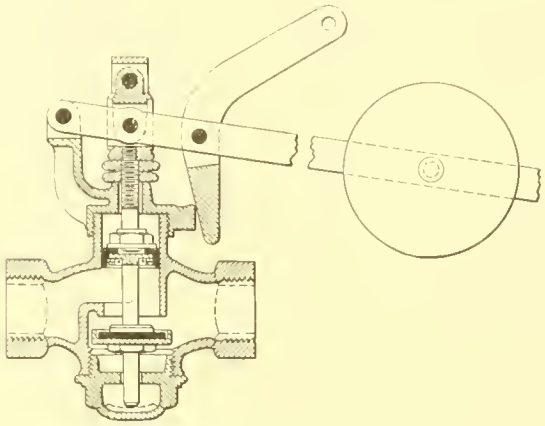


FIG. 13 SIMIN VALVE FOR TOWN FIRE SYSTEM, OPERATED BY A PRESSURE SURGE FROM THE MAIN SOURCE

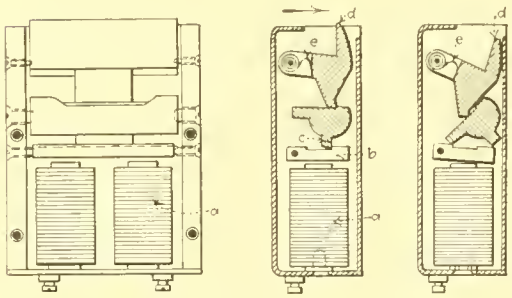


FIG. 14 VALVE OPERATED BY ELECTROMAGNETS

with condensation. The number of stages in the case of reaction turbines is indicated in Table 5.

TABLE 5 NUMBER OF STAGES IN REACTION TURBINES (GERMAN PRACTICE)

Output, kw.	1500	2000
Steam pressure, atmospheres gage	12	12
Temperature, deg. cent./fahr.	300/572	300/572
Vacuum, per cent	97	95
Speed, r.p.m.	1500	1500
Number of pressure stages	two-rim impulse wheel and 50 stages	no impulse wheel, 71 stages

The new types of reaction turbines and impulse turbines of the Zoelly type are provided nearly always with one high

pressure impulse wheel which is usually made with two and sometimes three velocity stages. It was found that during 1912 the Zoelly impulse turbines have been built with smaller numbers of stages. When lower speeds are used, the number of stages is generally larger than with higher speeds, which is of course required in order to obtain good peripheral velocities with a diameter of wheel which is not excessive. The pure Curtis turbines are built mostly with two pressure stages and two velocity stages per pressure stage, and only seldom with more pressure stages.

Governing. A universal effort has been observed to make governing as sensitive as possible. All the concerns building turbines are passing from pure throttling governing to a combined system of governing or nozzle governing, which is more economic at partial loads. Nevertheless in the largest number of turbines, especially small turbines, now in operation throttling governing is used, which is due to the fact that combined governing in the case of reaction and Zoelly turbines has become possible only through the introduction of the high pressure Curtis wheel. In the majority of cases the governing is operated by means of a servomotor which usually works with oil under pressure. The latter system is replacing former designs where steam was used as motive power. The sealing of stuffing boxes is done nearly exclusively by steam, and cases where oil or water is used as sealing liquid are comparatively rare. The use of oil is undesirable on account of the possibility of the oil penetrating into the water of condensation, which would destroy the advantage which steam turbines have with respect to reciprocating engines. The regulation of the steam sealing pressure is done nearly always by hand, and automatic devices for this purpose are provided in only rare cases.

The safety of the operation of steam turbines is generally considered very high, but it is claimed that a steam turbine requires the same care in attendance as reciprocating engines. It is also noticed that the cause of breakage of steam blades can be in only rare cases established with certainty. It is sometimes ascribed to imperfect installation, at other times to non-uniform cooling of the rotor, while in many cases poor material has been probably the cause. It is also very likely that the properties of material are so affected by continuous work at high temperatures that the material cannot withstand the stresses which occur in it. Besides the blading, the layers of the cams and the servomotor require the most attention.

Generators. In the case of direct current generators the voltage seldom exceeds 500 volts. In polyphase and two-phase generators the voltage varies usually between 2000 and 3000 volts, and is often as high as 6000 volts. For still higher tensions 10,000 volts is usually selected. Direct current is found only in small plants. Noise produced by the generator sometimes exceeds permissible limits. It has been observed that it may be reduced by passing the cooling air, not into the machine room, but direct into the atmosphere through a special passage. The air heats up in the generator usually to 40 or 50 deg. cent. (104 to 122 deg. fahr.), while temperatures up to 60 deg. cent. (140 deg. fahr.) are still permissible. Sometimes water cooling is provided. In nearly one-half of the generators the cold air is filtrated, which is done in order to prevent short circuiting by the deposits of dust; especially in turbogenerators, which have been installed lately, is such a device provided.

Condenser Plants. The prevailing type is the single surface condenser. Jet condensers are installed usually with turbines of small output, but sometimes also in large turbines up to 7000 kw. A central condenser has been found only in one plant, while in several cases jet condensers have been provided as a reserve to an existing surface-condenser system. In single condenser installations the pressure fall is so small that it can be determined only by a very exact measurement. In several cases a pressure of only 0.5 per cent had been observed, while the highest fall of pressure indicated is only 1.7 per cent. As regards the vacuum, the requirements are increasing all the time. In modern power plants a vacuum of 93 or 97 per cent is found, while even as high as 98 per cent is given as existing in a number of plants. The correctness of such data as 97 or 98 per cent is very often doubtful since, as Professor Josse has previously shown, it is very difficult to measure correctly high vacua; and it appears that in several cases where the control test of the vacuum can be made by measuring the temperature of the warm water of condensation, this temperature was higher than the saturation temperature corresponding to the given vacuum, and the difference was much larger than would be ascribed to errors of observation (from 10 to as much as 30 deg. cent. (18 to 54 deg. fahr.). It is therefore reasonable to suppose that in the most cases the high vacua from 94 to 98 per cent were not actually available.

It did not prove possible to express by means of curves the relation between load on the condenser and vacuum. With the vacuum of 93 to 97 per cent, the amount of cooling water equal to about 60 times that of water of condensation, and the cooling temperature of 15 to 20 deg. cent. (59 to 68 deg. fahr.), on the average, a load of 22 to 23 kg/qm. (4.43 to 4.63 lb. per sq. ft.) per hour has to be taken. The amount of cooling water per kg. of steam varies between 40 and 80 kg., the lower value being of course for colder cooling water and vice versa; on the average about 60 times the weight of cooling water is used.

For the packing of condenser pipes the use of stuffing boxes appears to be preferred, nearly two-thirds of all condensers being equipped with them. In other condensers the pipes are rolled in, the different types of packing being equally used both in small and large condenser units. The use of rubber rings is rare, unless stuffing boxes are also used. Sometimes the pipes are rolled in on one end and provided with stuffing boxes on the other, which permits the pipe to move freely.

As regards the types of pumps in connection with condensers the wet pump and the centrifugal pump for cooling water still predominate, owing to their simplicity and low cost. The wet pump is mainly driven by an eccentric from the main turbine. When the suction of the water of condensation and air are done separately, the centrifugal pump is mainly used. The suction of air by means of jet devices is still rare, owing probably to the fact that this kind of apparatus in a simple form has been introduced only recently.

It is worth while to notice that the power consumption of separately driven pumps is higher than when the pumps are driven from a common source, which may be ascribed to the fact that the losses in a number of small motors are generally larger than when one large source of power is used. The driving of the pumps by means of the steam turbine appears to involve a larger power consumption than

by means of an electric motor, probably due to the larger speed of rotation when a steam turbine is used.

The exhaust steam of the auxiliary turbine is nearly always used for the low pressure part of the main turbine. Direct feeding of boilers by means of a condenser pump taking water by suction from the condenser is met with only seldom, although this system admits the simplest automatic regulation of the water level in the boiler, and reduces the heat losses to a minimum. The additional water used for feeding the boiler is as a rule previously passed through a water cleaning device. Since the presence of oil in water of condensation of steam turbines is not expected, in no case is an oil separator device used, but it must not be forgotten that a certain amount of impurities may be introduced by the action of the condenser pumps, which may, however, happen only where wet pumps are used in the condenser plant, or where a separate suction of air and water of condensation is used, and the latter is handled by reciprocating pumps which use oil for lubricating their stuffing boxes. In more modern types of condenser plants the water of condensation is taken care of nearly exclusively by centrifugal pumps, so that all pollution by oil is eliminated.

Disturbances in the action of condenser plants are extremely rare, and when they occur they are mostly due to poor material or imperfection in handling the plant. The valves of the pumps must of course be inspected from time to time, as excessive wear may be a source of trouble, and in the case of air pumps may affect the vacuum.

Locomotive Cinders as a Fuel for Steam Boiler Furnaces (*Rauchkammerlösche als Brennstoff für Dampfkessel*, O. Nerger. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 52, p. 2067, December 27, 1913. 4 pp., 5 figs. *de*). There were numerous attempts to utilize for fuel purposes locomotive smoke box cinders which contain from 3500 to 4500 WE. (6300 to 8100 B.t.u. per lb.). But all such attempts have generally proved unsuccessful, owing to the difficulty of burning the cinders on any kind of grate, the grain of the cinders being very uneven, and varying from fine dust to pieces up to 5 mm. (or 0.2 in.). Several experiments have been made on burning such cinders together with coal rich in gaseous compounds on undergrate blast furnaces, such as the Kudlicz or Kridlo types, but these furnaces require that the charging, shifting of the fire and removal of clinkers be made by hand; so that frequent opening of the fire doors allows the entrance of cold air with its attending heat loss, and at the same time makes it difficult to maintain an even fire. Even at that, the cinders did not burn well and a large proportion of them were carried over into the ashes or sent out through the flue.

The tremendous amount of locomotive cinders obtained every year led the German engineers to experiment actively in order to find a system by which this kind of fuel could be burned *without* an admixture of coal rich in gaseous compounds. Attempts have been made to use special forms of arches, chain grates, inclined-step grates, and so on, but up to this time no attempts were successful in burning more than 40 per cent of the cinders in a mixture of high gas coals. It was only lately that the State Railway Administration Division of Breslau, in installing a large roundhouse at Oels, again made a series of experiments on the utilization of locomotive cinders for boilers with what appears to be fair success. They use a modified type of forced draft furnace with traveling grate of the Pluto stoker type. With the ordinary type of the Pluto stoker, the operation was not quite successful, as notwithstanding the motion of the hollow grate elements, the cinders have exhibited a tendency to bake together and in this way to interfere with the traveling of the fuel over the grate, which very unfavorably affected the steam output of the boiler. Further, the baking of the cinders prevented the air from reaching the fuel, resulting in incomplete combustion and the passage of a considerable amount of the cinders into the ashes.

The main advantages were secured by the introduction of steam into the hollow grate elements. After this was done, the slags remained fluid and did not form clinkers on the grate elements, the travel of the fuel over the grate became better and greater combustion velocities became possible. Further, the action of steam helped to obtain far more powerful combustion than was possible in the early experiments, the ashes were well burned out and contained only little combustible material. The other modifications were of a secondary nature and referred to regulation of velocity, distance of motion of the hollow grate elements, air pressure of the grate, etc.

These experiments have shown that with the modified Pluto stoker, it is fully possible to obtain a comparatively good efficiency of combustion with locomotive cinders. The main element of success in this test was a continuous breaking up of the fuel by the relative motion of the hollow grate elements which gave the air of combustion means of access to the fuel. The high combustion temperature required in this case has been made possible with the Pluto stoker by the use of a special fire return arch, Fig. 15. As shown, the brick work is arranged in a manner such that over the upper part of the grate there is only quite a short arch, the only purpose of which is to protect the header and the pipe connections against the action of the hot gases. On the other hand, there is a long arch over the entire lower part of the grate, fairly close to the grate. The flames, therefore, go not as in other systems of firing from the front backwards, but from the back forward, and a large amount of radiation is obtained, directed towards those parts of the fuel which have just reached the grate, so that the fuel has an opportunity to reach the temperature of ignition in the early zones of the stoker. With the gradual travel over its path of combustion, the fuel has plenty of time fully to burn out.

The main data of the tests are given in Table 6, which shows that with this system of firing comparatively great efficiency is obtained with cinders as fuel, the steam output is comparatively high and would probably be still higher if the tests had not been made with a boiler of somewhat antiquated design. The evaporation with respect to the fuel used is fairly good. The contents of carbon dioxide were as high as 9 per cent, which shows that quite a favorable excess of air had been secured. The flue gas temperature was comparatively high, which depended probably on the construction of the boiler, and the loss from this source could be considerably reduced by a better design. The slags and the ashes were well burned out and contained only traces of combustible material. The amount of ashes taken out by the flue was insignificant and contained little combustible material.

The author gives a cost calculation for three cases, using German cost data, and shows thereby that the use of loco-

motive cinders on a modified Pluto stoker gives a considerable economy over a chain grate on which are burned locomotive cinders together with ordinary coal.

Evaporation Tests of L. Weiss and the Law of Evaporation for Stationary Boilers (*Verdampfungsversuche von L. Weiss und das Verdampfungsgesetz für ortfeste Dampfkessel*, O. Köchy. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 52, p. 2070, December 27, 1913. 4 pp., 5 figs. *ctA*). The tests described were made with the boilers shown in Fig. 16, made possible by the fact that each of the boilers was divided into two parts with independent water feeds. The heating surfaces of the boilers were as follows:

	Qm.	Sq. Ft.
Fire tube with lower drum bottom.	29.59	320.19
Upper drum with water tubes	132.36	1424.70
Upper drum shell.	16.04	172.65
Lower drum shell.	22.61	243.35
Superheater	50.00	538.19
Grate area	3.68	39.60

The results of tests are given in Tables 7 and 8.

On the basis of these tests, and the author's previous investigation on The Law of Evaporation and The Law of Heat Transmission in Locomotive Boilers (*Zeitschrift des Vereines deutscher Ingenieure*, 1912, p. 520), the author established an equation which, in general terms, he expresses as follows:

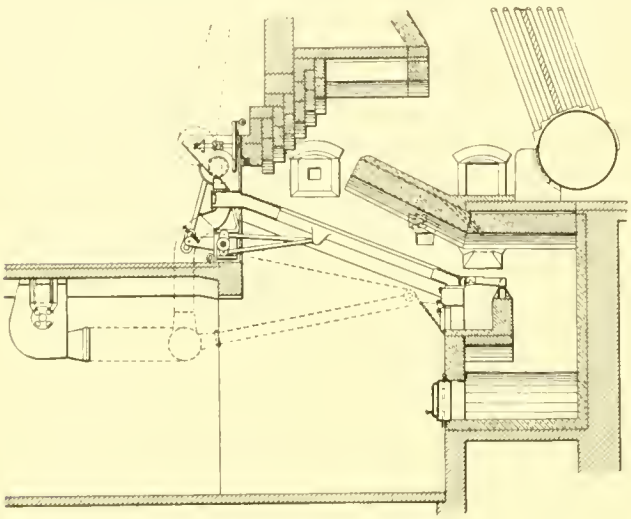


Fig. 15 Furnace of the Modified Pluto Stoker Type for Burning Locomotive Smoke Box Cinders

$$\theta_n = \frac{a}{b + \frac{H_n}{R}}$$

where H_n is a section of the heating surface of a boiler, in square meters, measured from the grate up to a certain point n on that surface; R is the grate area in qm, θ_n is the amount of steam generated per square meter of H_n per hour, in kilograms, while a and b are constants. These constants can be determined in the following manner: from Table 7 the evaporation per hour from the two lower drums with their shells was $\frac{17080 + 18970}{11} = 3280$ kg., and from the two upper drums and their shells: $\frac{7180 + 8700}{11} = 1470$ kg., and from all four together: 4750 kg. With a superheat $\frac{105 + 106}{2} = 105.5$ deg. cent., specific heat of superheated steam 0.552, and heat of evaporation $\lambda = 662 - 21 = 641$, the output of the superheater, in wet steam units, per hour, is $\frac{4750 \times 0.552 \cdot 105.5}{641} = 430$ kg., which brings the total output of the two boilers up to 5180 kg. Further let $H_2 = 2 \times 29.59 = 59.2$ qm., the heating surface of the two lower drums H_1, the heating surface from the grate to the end of the superheater, assuming that the latter, insofar as it participates in the transmission of heat, is

TABLE 6 TEST OF FIRING LOCOMOTIVE SMOKE BOX CINDERS

Date of test	June 20, 1913
Type of Boiler	Water tube
Heating surface.	125 qm. (1345 sq. ft.)
Firing system	Pluto stoker, 5.91 qm. (53.60 sq. ft.) grate area
Length of test.	3 hours
Fuel	
Kind and size.	Unscreened locomotive cinders, up to 0.4 mm. (0.015 in.) grain
Heating value	4061 WE (7309 B.t.u. per lb.)
Consumption: total	1690 kg. (3718 lb.)
per hour.	562 kg. (1236 lb.)
per hour per qm. grate area	95 kg. (19 lb. per sq. ft. grate area per hour)
Feedwater	
Total evaporation.	6330 kg. (13926 lb.)
Evaporation per hour per 1 qm. heating surface.	16.8 kg. (3.45 lb. per sq. ft. heating surface per hour)
Evaporation per hour per 1 qm. heating surface in terms of steam at 100 deg. cent. (212 deg. fahr.) and water at 0 deg. cent. (32 deg. fahr.)	17.7 kg. (3.64 lb. per sq. ft. heating surface per hour)
Temperature of feedwater	42 deg. cent. (107.6 deg. fahr.)
Steam	
Pressure, gage.	10.2 atmospheres
Temperature	275 deg. cent. (527 deg. fahr.)
Total heat	718 WE (1292.4 B.t.u.)
Heat produced in the boiler	676 WE (1216.8 B.t.u.)
Flue Gases	
Temperature at the boiler end.	310 deg. cent. (590 deg. fahr.)
CO_2 content at the boiler end	9 per cent
CO content	0 per cent
O_2 content	9.5 per cent
Pressure in the hollow grate elements.	12 mm. (0.5 in.) of water
Temperature of the air.	20 deg. cent. (68 deg. fahr.)
Heat Balance	
Useful output of boiler and superheater	2590 WE 4662 B.t.u.—63.5 per cent
Losses in the flue gas (free heat)	829 WE 1492 B.t.u. —20.4 per cent
Losses through radiation, incomplete combustion, etc.	642 WE 1155.6 B.t.u. —16.1 per cent
	4061 WE 7309 B.t.u.—100 per cent

replaced by an ideal wet steam heating surface. The exact value of H_2 is therefore as yet unknown.

$H_3 = H_2 + 2 \times 132.36 = H_2 + 265$ qm., the heating surface up to the end of the nest of boiler tubes.

$H_4 = H_2 + 265 + 2(16.04 + 22.61) = H_2 + 342$ qm., the total heating area of boilers, including the shells.

The values of these heating surfaces, with the values of the respective evaporations are tabulated in Table 9. The values of evaporation for H_1 to H_3 are somewhat inexact because they include the evaporation due to the shells, which properly belongs only to H_4, but the amount of evaporation from this source is quite insignificant.

For a first approximate calculation of the constants a and b the heating surface of the superheater is neglected, and H_2 made equal to $H_1 = 59.2$; hence $H_4 = 59.2 + 342 = 401.2$ qm., and from this it follows that the average evaporation per square meter is for

TABLE 7 L. WEISS TESTS OF EVAPORATION IN A SCHWOERER BOILER

Boiler No.	2919		2920	
Steam temperature, deg. cent.-fahr.	288	550.4	289	552.2
Superheat, deg. cent.-fahr.	105	189	106	190.8
Temperature of feedwater, deg. cent.-fahr.	21.2	70.2	21.3	70.4
Coal consumption, kg.-lb.	3001	6602	3350	7370
Evaporation in lower drum, kg.-lb.	17080	37576	18970	41734
Evaporation in upper drum, kg.-lb.	7480	16456	8700	19140
Heating value of coal, WE-B.t.u.	7428	13370	7428	13370
CO_2 content in flue gases, per cent.	12	12	12	12

TABLE 8 AVERAGE TEMPERATURE OF FLUE GASES

(Measured at Points indicated in Fig. 16)

	Deg. Cent.	Deg. Fahr.
At exit from fire tube	872	1601.6
At entrance to upper drum	720	1328.0
At exit from upper drum	342	647.6
Flue gases at damper	243	469.4
Average gas temperature, superheater	470	878.0

TABLE 9 PARTIAL HEATING SURFACES OF THE BOILER UNDER TEST, AND THEIR RESPECTIVE EVAPORATIONS

Heating Surface H_n in qm.		Evaporation in kg. per hour, $\theta_n H$
$H_1 = 59.2$		$= 3280$
H_3	$3280 + 430$	$= 3710$
$H_1 = H_2 + 265$	approximately same as H_4	
$H_4 = H_2 + 342$	$3280 + 430 + 1470$	$= 5180$

TABLE 10 HEAT TRANSMISSION

H_n	θ_v Kg.	T_n Deg. Cent.	$T_n - t$ Deg. Cent.	$C = T_n - t / \theta_v$ Deg. Cent.	Corrected T_n' Deg. Cent.	Corrected $T_n' - t$ Deg. Cent.	Error $\phi = \left(1 - \frac{T_n'}{T_n}\right)$ PerCent
H_1	55.4	872	689	12.4	847	664	0.03 = 3
H_2	46.7	720	537	11.5	738	555	−0.023 = −2.3
H_3	14.9*	342	159	10.7	361	178	−0.053 = −5.3
H_4	12.3	243	60	4.9	331	147	

* Calculated value of θ_1.

$$H_1,\ \theta_1 = \frac{3280}{59.2} = 55.4 \text{ kg.}$$

and for

$$H_4,\ \theta_4 = \frac{5180}{401.2} = 12.95 \text{ kg.}$$

from which the following equations may be derived for the determination of a and b (with $R = 2 \times 3.68 = 7.36$ qm):

$$55.4\left(b + \frac{59.2}{7.36}\right) = a, \text{ and } 12.95\left(b + \frac{401.2}{7.36}\right) = a,$$

hence $b = 6.15$, and $a = 788$, and the equation expressing the law of evaporation may be expressed, in its first approximation, as follows:

$$_n = \vartheta \frac{788}{6.15 + \frac{H_n}{R}}$$

Now, since

$$\vartheta_2 H_2 = \frac{788 H_2}{615 + \frac{H_2}{7.36}} = 3710 \text{ kg.}$$

it follows that $H_2 = 80$ qm. Knowing H_2 it would be possible to calculate a, b and ϑ_n in the second approximation, but this does not appear necessary because, as the author shows, the first approximation gives sufficiently correct results.

In his investigation of evaporation processes in locomotive boilers the author proved that the transference of heat is proportional to the square of $T_n - t$, difference between the temperatures of the heating gases and the boiler water, which leads to the following equation:

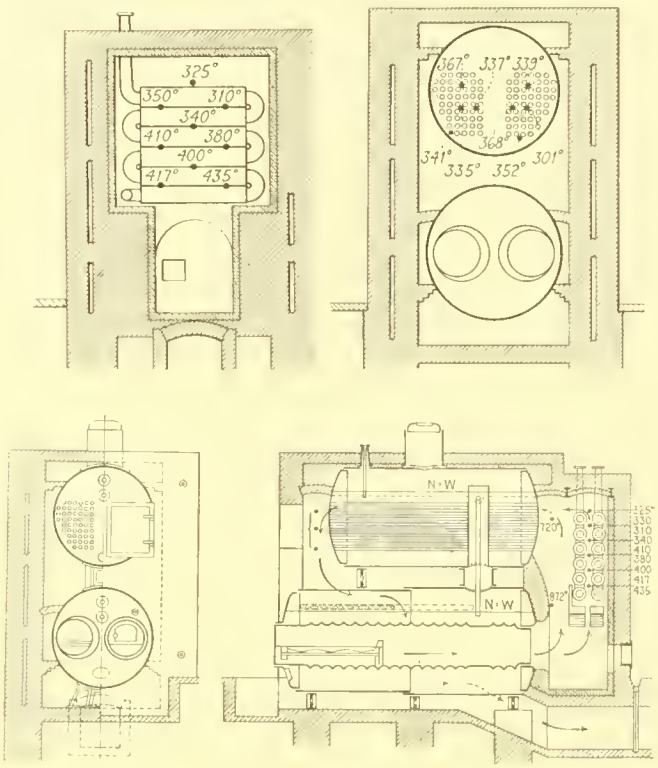


Fig. 16 Schwoerer Double Flue Boiler with Superheater

$$(T_n - t) c_p (1 + L)\beta = \frac{ab\lambda}{b + \frac{H_n}{R}} = \theta_n b \lambda,$$

where T_n is the temperature of the furnace gases at n, t the temperature of the boiler water (183 deg. cent. = 361.4 deg. fahr.); β the weight, in kg., of coal burned per hour per 1 qm. of the grate area; L the weight of the air required for burning 1 kg. of coal, and $c_p = 0.25$, specific heat of the heating gases. From this equation it follows that

$$\frac{T_n - t}{\vartheta_n} = \frac{b\lambda}{c_p(1 + L)\beta} = C$$

and that C is constant, since all the members of the right side of the equation are constants. Therefore, if it could be proved that in stationary boilers the preceding equation holds good, that would also show that the above enunciated law as to the magnitude of transference of heat applies to

stationary as well as to locomotive boilers. Table 10 shows the values obtained. The deviations of the first three values of C from a fixed average the author ascribes to unavoidable errors of observation and accidental influences. In third and fourth line the rapidly growing discrepancies are probably due to heat given up to the brickwork. By assuming for C the average value from the first two lines, $C = \frac{12.4 + 11.5}{2} = 11.95$, the author obtains a basis for the calculation of the last three columns of his table.

The last two equations may be used for various calculations, e.g., for determining the weight of flue gases. Since

$$\frac{T_n^1 - t}{\vartheta_v} = \frac{b\lambda}{c_p(1+L)\beta} = 11.95$$

and the weight of coal burned per square meter of grate area per hour is 78.3 kg., it follows that

$$1 + L = \frac{6.15 \times 641}{11.95 \times 0.25 \times 78.3} = 16.9 \text{ kg.}$$

The author shows also how the efficiency of the boiler and coefficient of heat transmission may be determined.

Single Cylinder Engine with Drawing-off of Receiver Steam (*Eine Einzylindermaschine mit Zwischendampfentnahme*, C. Pfleiderer. *Zeitschrift des Vereines deutscher Ingenieure*, vol. 57, no. 51, p. 2030, December 20, 1913. 6 pp., 26 figs. *de*). The steam engine is better able to compete with other prime movers when the heat in the steam, after it has done its work in the cylinder, is further utilized for heating or cooking purposes. When for the latter purpose hot steam is required, it is taken from the receiver between the high and low-pressure cylinders, and it has been found that when a very large proportion of the total steam generated is taken for outside purposes in this way, the low-pressure part, with its consumption of space, interest and depreciation charges, lubrication, etc., ceases to pay for itself. In fact it may be said that when one-half of the exhaust steam is let out into the atmosphere with a pressure above one atmosphere, while the other half is used for heating purposes, the results are more satisfactory economically than when the low-pressure cylinder with its condensing plant are used. In small plants, of course, the single-cylinder engine is the naturally used type, while, with high superheat and elimination of all unnecessary clearances, it is as economical in its steam consumption as a multicylinder engine, so that often it is only the demand for steam for heating purposes that prompts the adoption of compounding. To obviate this, Thyssen & Company, of Mühlheim-Ruhr, Germany, have evolved the Missong engine, a single-cylinder engine with a provision for obtaining receiver steam for heating and other purposes.

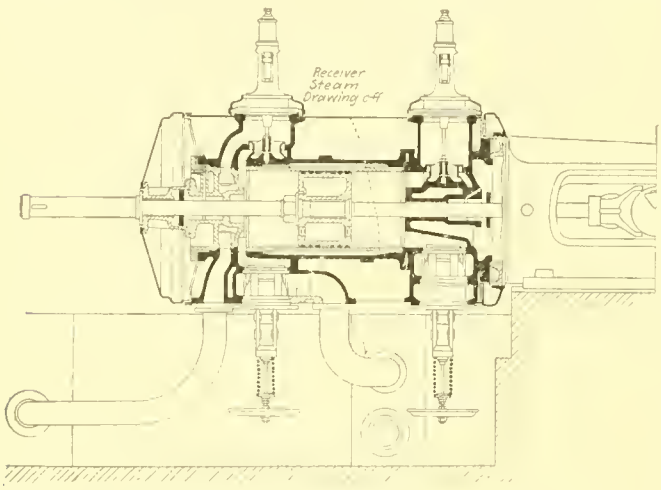


Fig. 17 Missong Single Cylinder Compound Engine with Receiver Steam Available for Heating Purposes

As shown in Fig. 17, the high and low-pressure cylinders are really combined in one, and lie on the two sides of a simple piston moving in a smooth cylinder. When the steam spaces on both sides are fully utilized, this arrangement corresponds to a compound engine with a ratio of cylinders as 1 : 1. With this ratio a large amount of receiver steam is available, while the engine has such a small low-pressure cylinder that the latter can work economically with what steam it gets. Further, as most of the oil is supplied to the low-pressure end of the cylinder, not only the lubrication can easily be maintained in perfect order even with large amounts of steam drawn off, but the steam used for outside purposes is comparatively free from oil, and may therefore be used direct, without previous oil separation. The difficulty of the proposed arrangement lies of course in the fact that when the demand for receiver steam is small, the small size of the low-pressure cylinder will interfere with the proper working of the engine, but the inventor obviated this by making the effective volume of the high-pressure cylinder variable in accordance with the demand for receiver steam.

The obvious way to do it was by varying the exhaust lead hand in hand with the admission. Fig. 18A gives an indicator diagram showing this system. Point I shows the exhaust lead when no steam is drawn off. The effective stroke in the high-pressure cylinder is here s_h, the effective volume ratio is $s_h : s_n$. During the remainder of the stroke s' the piston sucks only steam from the receiver, to throw it out again on the return stroke, which is uneconomical. With increasing admission in the high-pressure cylinder, which may be produced by an increase in the drawing off of receiver steam, the exhaust lead must decrease, and point II shows its limit for a drawing off of 56 per cent, with a 32 per cent admission in the low-pressure cylinder. When the governor acts at the same time on the admission and exhaust lead, all the processes of compounding will be reproduced in a single-cylinder engine, though with some losses, owing to the fact that part of the stroke is "dead." Another system was therefore adopted, with the variation in the high-pressure cylinder volume being effected through an alteration in the degree of compression (cp. Fig. 18B). When less steam is taken from the receiver, some of the steam let into the high-pressure cylinder is forced back into the live steam piping, i.e., the compression is increased, which is equivalent to a reduction of the high-pressure volume: the contrary expedient is adopted when the drawing off of steam is increased. In order to avoid formation of loops in the diagram, the admission lead is also placed somewhat in advance, so that the loop formation is reduced to the amount corresponding to the flow resistance in the valve gear. As shown in Fig. 18B, with no drawing off of steam the admission lead begins at I, the effective high-pressure volume is equal to s_h, the passive to s'. With increasing drawing off of steam, i.e., increasing admission, s_h increases and s' decreases, just as in the preceding case, which indicates that both systems of governing are in full accord with

one another. The Missong engine is therefore a single-cylinder compound engine, with possibility of using receiver steam, and the ratio between the high and low-pressure volumes varying in accordance with the consumption of receiver steam. Although the volume ratio of 1:1 is fully unsuitable for an ordinary compound steam engine, even when no receiver steam is drawn off, the characteristic of compounding is fully maintained, the work of the steam being divided between the high and low-pressure cylinders in a manner such that the drop in temperature in both of them is equal. Of course the back pressure due to the flow of steam back into the live steam piping represents a certain loss of energy, but that may well be overlooked since the engine is destined to work normally with the drawing off of receiver steam, and the ratio of cylinders convenient for this purpose does not permit of making the low-pressure cylinder work with the usual small admissions.

The problem of the valve gear (Fig. 19) in the Missong engine is somewhat complicated by the fact that not only the admission, but also the compression and admission lead in the high-pressure cylinder, are variable. The governor for the receiver pressure also takes care of the regulation of compression and admission lead as well as the admission on the high-pressure side, the latter decreasing as the compression increases. The regulation is accelerated through the variation in admission owing to the fact that it thus receives less steam when it wants less; losses of power through back pressure in the live steam piping are reduced, and exhaust lead of the high-pressure cylinder increased. *The influence of the pressure regulator is, however, limited to the high-pressure side only.* The velocity regulator adjusts the power output to the demand by varying the admission on the low-pressure side. This system of governing is claimed to give satisfactory results. Thus, when, with a decrease in the amount of steam drawn off from the receiver the pressure regulator sets in on the high-pressure side higher compression and smaller admission, the falling off in output is compensated for by the velocity regulator increasing the admission on the low-pressure side; more steam is taken from the receiver, the pressure in it falls, and the pressure governor begins to act in the same way as the velocity governor. A variation in load is also taken care of by the governors. If the load decreases, the velocity governor reduces the admission to the low-pressure cylinder; less steam is taken from the receiver, and the pressure in it rises; this causes an increase of compression and decrease of admission on the high-pressure side, with a reduction in the amount of steam entering into the engine.

The original article gives data of tests of the Missong engine with numerous indicator diagrams.

The 15th Annual Meeting of the Society of Naval Constructors (*Die XV-Hauptversammlung der Schiffbautechnischen Gesellschaft,* O. Flamm. *Schiffbau,* vol. 15, no. 5. Article not finished). The article contains full data of the paper read at the German Society of Naval Constructors by one of the directors of the Hamburg works of the Vulkan Company, Dr. Bauer, and the discussion which followed it. The main subject discussed in the paper is that of turbine blade ruptures. These ruptures, according to Dr. Bauer, are due, first to unsatisfactory material, and second to poor design and operation of the apparatus. As to the design, strict attention must be paid to proper dimensions of the blades, and to the provision of sufficient axial and radial clearances, especially when superheated steam is used. The blades should be interconnected by wire or bandages, and thus made to support one another. The reversing turbine is always a source of danger as far as the safety of the blades is concerned. As to the immediate cause of ruptures of blades, the author did not put much weight in the possibility of foreign bodies getting in among the blades and thus producing breakages; in most cases where such a reason was cited, the accident was probably due to some other cause. A steam screen in front of the admission port would in any case keep all foreign matter out. If such a foreign body did happen to get in, far less damage would

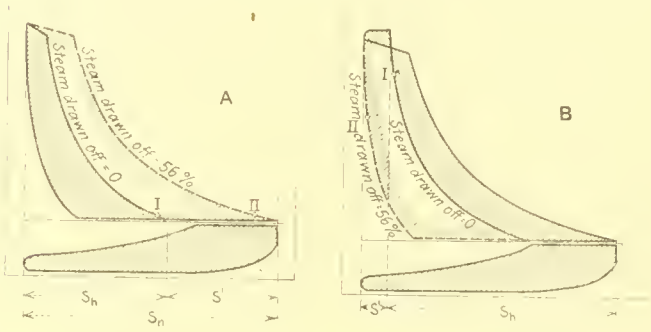


Fig. 18 Indicator Diagrams illustrating various methods of governing

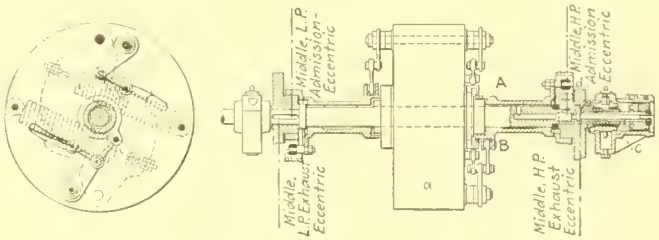


Fig. 19 Valve gear of the Missong Single Cylinder Compound Engine

be done if the blades were running in one direction only than if a back turbine were also being used. Improper operation was more often the real cause of accidents; under this head may be mentioned the action of water hammer, which is particularly likely to occur in plants having reversing turbines. As the manoeuvring apparatus has to be used particularly in harbors, accidents from water hammer are especially apt to occur there. If a large amount of water is thrown into the turbine from the boiler, owing to excessive boiling, no harm will be done as long as the turbine runs always in one direction; the critical situation arises only when large masses of water are thrown suddenly against the blading by the steam, as may happen at starting or reversing. For transmission from the turbine to the propeller the author recommended the Foettinger transformer in preference to gear transmission.

These views called forth considerable opposition. Mr. Roth, engineer at the Schichau works, did not share the speaker's view as to the dangers from the presence of a reversing turbine, and said that effective and convenient reversing turbines for reversing may now be built. The disadvantage of the transformer lies in its low efficiency, some 6 per cent below that of chain drive. Mr. Eggers, director of the

Schmidt Superheater Company, spoke briefly of his tests of a 10,000-h.p. Foettinger transformer; after a 14 days' uninterrupted run the tests were arranged so as to either break the transformer down, or show that it cannot be broken down; the apparatus stood the severe conditions of the test, and thus proved its reliability. All the speakers emphasized the fact that indirect drive was what was to be expected to be universally adopted in the future.

Alsacian Association of Steam Machinery Owners, Report of the Work done in 1912 (*Association alsacienne des propriétaires d'appareils à vapeur, Rapport sur les travaux exécutés en 1912, Bulletin de la Société Industrielle de Mulhouse,* vol. 83, no. 9, p. 697, November 1913. 82 pp. *gs*). The main work done by the association consists in the inspection of steam apparatus, either in the regular course of business, or by invitation of the owners, or finally on account of some accident which happened in a plant on the lists of the association.

In this report full data of such accidents, with their causes, are given, as well as general remarks on steam plant conditions in the district, and some data of tests carried out by the officers of the association. The following remarks are of general interest:

Steam piping is not covered by precise legislation, and is not therefore under the special control of the association or any other organization. Nevertheless there are just as many accidents due to steam piping as to steam apparatus proper. As the pressure and temperatures of steam tend to go up, high pressure piping becomes subject to considerable stresses due to internal pressure or expansion, and this makes it absolutely necessary, in order to avoid accidents, to use first-class metal and careful and sensible work in the installation of the piping. As a matter of fact, however, the piping is often very much neglected, and while in new installations all sorts of precautions are taken with the boilers and engines, very little interest is often shown as regards the safety of the piping.

It is in the manufacture of steam piping especially that autogenous welding is used. Pieces difficult to manufacture by forging or ordinary welding can be made by this process, and when used with discernment and sufficient care it is a great help in the installation of piping systems. But according to the council of the association this process is unsuited for use in systems carrying considerable pressures, pipes in which the longitudinal seam has been joined by autogenous welding. During the year to which this report refers, the association had a striking example of this fact in a case where the piping designed to carry exhaust steam at 4 kg. per sq. cm. (56.8 lb. per sq. in.) had to be replaced by weldless piping. Some of the pipes made by autogenous welding broke when the joints were put on. Another pipe opened during the operation along the weld a distance of 60 cm. (15 in.). It must be stated, however, that in addition to defective welding, the pipes in this case were not strictly cylindrical.

The association has been instructed by the International Union of Boiler Inspection Associations to study the influence of the circulation of water on the transmission of heat in economizers and has performed during the year 1912 a series of experiments, which, together with the experiments on economizers during preceding years, has given a considerable amount of material bearing on this subject.

The system of water circulation, i.e., the simultaneous ascension of water in the tubes and the horizontal flow of gases around these tubes, which has always been applied by Greene & Son, inventors of the economizers, has seemed unreasonable to certain designers. These have insisted on the necessity of a more systematic circulation and have either divided the feed heater into several sections, or have carried to the extreme the principle of the countercurrent circulation, in forcing the water to circulate alternately from bottom to top, and from top to bottom in a series of successive tubes. This question has caused an animated discussion which has been rather strengthened than appeased by the comparative tests which were made some five or six years ago at the mechanical laboratories of the Bavarian Association. The present tests have shown that, (*a*) the increase of the speed of water in the feed heaters increases to a small extent the coefficient of transmission of heat; and (*b*) all changes in the circulation of water with respect to the gases which approach the real countercurrent circulation, all other conditions being equal, increase the total quantity of heat transmitted and the efficiency of the feed heater; but this increase depends to a large extent on the relative dimensions of the feed heater with respect to the quantity of water and hot gases, in the sense that the larger the feed heater, the more reason there is for using methodically installed countercurrent circulation.

The report also contains material on steam turbine tests as well as fuel tests of various types of machines, and tests of Diesel engines.

ENGINEERING SOCIETIES

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Bulletin, vol. 15, no. 161, November 1913, Chicago

The Air-Seasoning of Timber, Wm. H. Kempfer (Abstracted)
Rolling Loads on Bridges, J. E. Greiner
Discussion on Rolling Loads on Bridges (Various Authors)

The Air-Seasoning of Timber, Wm. H. Kempfer (67 pp., 63 pp., bibliography. *gp*). The article is composed from data obtained by the United States Forest Service and is very interesting as a clear presentation of all the material collected.

As regards southwestern woods, ties cut in January and February require from four to five months to reach a constant moisture content. As the season advances, the rate of evaporation is very much increased. Ties cut in May and June required a much shorter time to reach constant weight—from two to one month. Not much change occurs in this weight until November, while the November and December ties reach a constant weight in about six months. Very little difference was found in the rate of seasoning of black and of red pine, but the total loss of weight was usually greater for the black pines. This would be expected because rapidly growing trees generally contain more sapwood and hence more moisture than the slower growing trees of the same species. This applies, however, only to most coniferous woods, but not necessarily to the broad leafed trees or hardwoods.

Although climatic conditions of the northwest are different from those in the southwest and vary also throughout the region, the same grouping of the ties can be employed

in all places and the effect of the time of year when the tests are started is very evident.

Lodgepole pine in Montana cut in May, June or July was practically air dry in three months, and even if started in September it became fairly well seasoned before winter; but if started in winter it did not become dry until July of the following summer. The rainy season may also affect the rate of drying.

In the case of southern pines, the influence of variations in meteorological conditions with the time of year is also quite marked, although conditions seem favorable to a rapid drying throughout a large portion of the year.

The rates of seasoning for loblolly and short leafed pines at Silsbee, Texas, for example, resemble each other very closely, but the long-leafed pine dries a little more quickly. However, the total weight loss is much less. The southern hardwoods in general differ from the coniferous in the slower rate at which they lose moisture and the longer time they require to become air dry. Ties cut in the spring and early summer in Arkansas were far from dry when they ceased to lose weight at the approach of summer, and during the following summer they lost nearly two thirds as much moisture as during the first summer. Data on the rate of seasoning hardwood ties in the north are very meager. The author gives also data on seasoning poles and cross-arms which do not materially differ from the seasoning of ties.

As regards the factors which influence the rate of seasoning, the author refers to climatic and meteorological conditions, species, and form of timber, manner of exposure and soaking. Variations in the rate of seasoning among species may be due to differences either in moisture content or the permeability of the wood. As to possible deterioration of the wood while seasoning, the author points out that ties or other timbers sometimes decay before the end of seasoning, but it is believed that this can be prevented by piling timbers so as to dry rapidly. The tree should be barked as soon as felled and the timbers piled openly. On the other hand, however, quick seasoning is not always desirable, because timber cut and set drying in hot weather checks more seriously than in cold weather and sometimes becomes "case hardened" and very resistant to preservative treatments. Information is also collected on the degree of dryness obtainable, shrinkage of volume of the wood due to drying, specific gravity and weight of wood. The article is accompanied by numerous tables and diagrams.

AMERICAN SOCIETY OF BREWING TECHNOLOGY

Journal, vol. 4, no. 1, October and November 1913, Chicago

Deep Well Compressed Air Pumping, James P. Gillies (Abstracted)

Use of Superheated Steam for Boiling Beer Wort, and Detrimental Effect on Copper

Deep Well Compressed Air Pumping, James P. Gillies (15 pp., 8 figs. *cdp*). The paper describes compressed air pumping on the air lift system. This method of pumping has been long considered to be very reliable and capable of obtaining the greatest quantity of water from a well of a given size. Usually, however, the air lift was installed only as a last resort under conditions that seriously handicapped it. It is only very lately that air lifts have begun to be installed in a proper manner and the high efficiencies now obtainable are due to the high state of perfection of the air compressors, better method of introducing the air into the eduction or water pipe, and to the proper proportioning of the pipes themselves. The modern air lift is so arranged that a constant stream of air and water is mingled, the air being broken up into small particles and an emulsion formed. This is forced through ventura to give the jet effect and each separate minute air bubble by its expansion carries its quota of water, resulting in a constant discharge with the minimum amount of slippage. The eduction pipe must be filled with air and water, and if it is too large for the amount of water, then a larger amount of air must be used to keep up the velocity.

Another thing that should receive attention is the enlarging of the eduction pipe towards the surface to allow for the expansion of the air upon its way to the surface. The changes, however, should not be abrupt and should not be carried to the extent that the air will be allowed to pass the water. The eduction pipe should be smooth. If the ends do not butt in the coupling but a short space is left between the pipe ends, swirls are produced and the air obtains an opportunity to slide past the water, which it has always a tendency to do.

The air lift system when properly installed may be very efficient even for deep well pumping. Thus the author quotes a case of several plants in Chicago where in each case the water is lifted more than 200 ft. at a cost that equals the best practice by any other means and in quantities unobtainable under the conditions in any other way.

As regards the cost of installation of the air lift, in small units, say under 300 gal. per min., it is slightly in excess of other competent methods. From 300 to 800 gal. per min. the cost is about equal, and above this limit the air lift has a decided advantage from the point of view of cost of installation. This is of course considering the total cost of plant, including the wells, the difference in favor of the air lift being due to the fact that fewer wells are required for an equal amount of water.

As regards maintenance of cost, the air lift once installed remains put indefinitely. Nothing comes into contact with the water except air and pipe. The only machinery used is located where most suitable, under the eye of the operating engineer, and any number of wells may be operated through the same compressor, provided its capacity is great enough, without regard to the location of the wells themselves. In addition to that, as far as the air lift is concerned, sand and solids in the water are not detrimental and do not have to be screened off. The air lift draws out the sand and sludge, enlarges the water bearing cavities and so increases the flow.

In the discussion which followed, G. J. Patitz pointed out that the air lift requires also a certain amount of attention, and it is necessary in most places to pull it out every two years or so, and often renew some sections of the piping used in connection with the air lift as they are usually subject to corrosion.

Mr. Christmann described some tests which he made at the plant of the Gottfried Brewing Company, with the deep well center pump and air pumping, of which the air pumping was very successful. The well, which is 12 in. reduced to 8 in. bore, 1658 ft. deep, was first fitted up with a motor-driven deep well center pump. After tests for several months, it was found that it could not give the amount

of water required. The proper sized air compressor was then installed and since then the system was running very satisfactorily, working 24 hours every day.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. 25, no. 4, November 1913, Washington

Description of the U. S. Fleet Collier "Jupiter," Lieut. S. M. Robinson, U.S.N.
Stresses in Marine Shafting, Ernest N. Janson (Abstracted)
Some Notes on Gyroscopic Action, Wm. L. Cathcart
Development of the Modern Gas Engine, Commander J. E. Palmer, U.S.N.

STRESSES IN MARINE SHAFTING, Ernest N. Janson (30 p., 11 figs. *t*). Stresses in shafting of marine engines may be classified as, (*a*) known stresses, which are determinable by the ordinary laws of physics, and therefore may be allowed for; and (*b*) unknown stresses, which are not determinable from the ordinary engine forces, but may be established by directly measuring the torque by special torsion meters, such as would indicate the fiber displacement of the shaft continuously for one or more revolutions.

The known stresses may be enumerated as follows: (*a*) Stresses due to forces exerted by the pressure of the steam in the various engine cylinders; (*b*) stresses due to inertia of moving parts of machinery; (*c*) stresses due to the bending influence in the crankshaft by direct action of steam forces and in the propeller shaft by the weight of propellers and pitching of the ship. These stresses are fully discussed in the article and various test data given.

Among the "unknown" stresses are to be found the following: (*a*) torsional vibration stresses; (*b*) stresses brought on by distortion in alignment of bearings either as a result of wear in the bearings or weakness of hull, and in foundations; (*c*) stresses resulting from defects in the material, or running afoul, or reactions of propeller due to pitching. The last two types of stresses are allowed for by employing "safe" stresses per square inch of section in the calculations used to determine dimensions.

Torsional vibrational stresses are not commonly allowed for either as an additional stress or by a reduction in the strain permissible per square inch of material. Regarding the additional stress brought on shafting by want of alignment, John H. MacAlpin in his paper on Crank Shafts[1] shows that when the bearing immediately forward of the after crank is only 0.001 in. out of alignment, there is an increase of 0.3 of 1 per cent in the strain beyond what is due to ordinary forces.

The subject of torsional vibrations is discussed on the basis of the paper of Herrman Frahm,[2] as well as the papers of G. Bauer and L. Gümbel, the author applying the formulae there obtained to the case of U.S.Ss. *Connecticut*, *Delaware*, and *Pennsylvania*. He points out that the critical number of revolutions of the fourth order of many engines of naval vessels often constitute also the cruising speed of the ship; and although the power at this speed is greatly reduced, the stress of the shafting due to the equivalent combined twisting moment becomes approximately equal to shafting stresses as large as when the engine is developing the full power. These stresses fluctuate between zero and the maximum value in one direction, and zero and a maximum value in the opposite direction, the twisting action of the shaft thus being reversed several times during each stroke, the number depending upon the type of engine.

The first accident to one of the crankshafts of the U.S.S. *Connecticut* occurred after having made approximately 34,150,000 revolutions with an average stress of about 14,000 lb. per sq. in. The existence of a considerable increase of stress in shafting of reciprocating engine shafts due to synchronous torsional vibration at normal, or cruising speed of naval vessels, and to overloading or other conditions such as sudden reversal, striking of floating bodies, etc., renders it reasonable to assume that shafting with a design shear stress of 10,000 lb. per sq. in. of section becomes severely overstrained; this design stress may be lowered in the interest of greater safety even at a sacrifice of greater weight or cost of increased dimensions.

It is interesting to note that the designed shear stress in line and propeller shafting for marine steam turbine installations seldom exceeds 6500 lb. per sq. in. of section of steel of 80,000 lb. tensile strength when working merely at a uniform torque. This shafting, therefore, in comparison with reciprocating engines, is working under far more favorable conditions with the result that accidents in the form of breakage are of rather rare occurrence.

The problem of making a meter for indicating torsion in the case of reciprocating engines is made somewhat complicated by the fact that the forces acting in this case create a continuous to and fro motion, and what may be termed "twisting and untwisting" of the shaft, the magnitude of which varies continuously during every revolution and between them. Such meters have, however, been made of a combined electromechanical type with some degree of success, but have not been extensively applied, owing to the necessity for considerable skill on the part of operators, and errors in interpreting records. A purely mechanical torsion meter with direct shaft connections giving a continuous record of torque for a number of revolutions would be of great value in obtaining reliable data in connection with the rather uncertain and difficult subject of calculating the stresses in marine engine shafting.

THE CONCRETE INSTITUTE

Transactions and Notes, vol. 5, p. 1, October 1913, London

The Settlement of Solids in Water and Its Bearing on Concrete Work, J. S. Owens
Steel Frame Buildings in London, S. Bylander
Economy in Reinforced Concrete Design, John A. Davenport
The Strength of Cement, H. C. Johnson (Abstracted)
Reports of the Reinforced Concrete Standing Committee (Cracks in Concrete and The Surface Treatment of Concrete)

THE STRENGTH OF CEMENT, H. C. Johnson (40 pp., 2 diagrams, 2 figs. *eA*). The author made tests of 15 different brands of cement used in paste, mortar, and concrete, and gives full data of these tests indicating the various brands, mainly English, by numbers. Some general conclusions arrived at are here reported.

Fineness, apparent density and specific gravity have been found to be closely related to one another. While the test for fineness is always valuable as a guide to a carefully pre-

[1] Journal of the American Society of Naval Engineers, November, 1896.

[2] Reprinted, vol. 14, Journal of the American Society of Naval Engineers.

pared and economical cement and is a constant quantity for a given cement, the apparent density and specific gravity vary with age. But when the approximate ages of cements sent for a comparative test are known, the three tests are all valuable: fineness, since it gives the percentage of binding material in the whole; the apparent density, because it indicates the volume for a given expenditure; and specific gravity, because low ones indicate ill-proportioned binding material for mortars and concretes, although they may be satisfactory for paste.

As regards cement mortar tests, the value of fine grinding has been brought out as well as the superiority of the mortar test over the paste test as a guide to the binding value. Certain general points have also been brought out: A decrease in strength in tension at 90 days as compared with 28 days does not necesarily indicate a decrease in compression. At 90 days the difference in strength between specimens with high and low percentages of water is very small, and in the case of the air-cured specimens it seems an advantage to have a higher percentage of water. The higher percentages of water have a greater effect on the tensile strength than on the compressive. But all cements do not give their greatest strength with the minimum amount of water it is possible to use. While the low percentages of water give a higher strength in the earlier ages, in the majority of cases there is very little falling off at 90 days due to the increase of water. In fact, one might reasonably expect that with a good cement the higher percentages would eventually produce a stronger material.

Concrete tests have given a strong argument against purchasing cement by weight and using it by volume. In the case of a light cement, a greater volume is received for a given weight. It is then used by volume with the result that the job suffers and the contractor benefits, the reverse taking place when a heavy cement is used. On the other hand, a heavy cement, if the specific gravity is high, is naturally coarser and then the job suffers as well as the contractor—the job, because the percentage of binding material is reduced, the coarse particles having practically no value, and the contractor, because he receives by volume a much smaller quantity for his ton.

The author also found that good strength in paste was not a proper indication of good strength in concrete. The best tests of a cement value for reinforced concrete or similar work are mortar compression cured in water and mortar compression cured in air, any cement having a higher value in air than in water to be condemned. For a given expenditure on cement, a first-class material will allow a saving, since there will be less cement to pay carriage on, less cement to handle, and at least as strong a concrete.

The author considers the system of selling cement in paper bags, as done in the United States, preferable to the use of canvas bags, as is the custom in Great Britain. Complete data of the tests with diagrams are given in the original article.

SOUTH AFRICAN INSTITUTION OF ENGINEERS

Journal, vol. 12, no. 4, November 1913, Johannesburg

Air Consumption and Maintenance Costs of Rock Drills, E. G. Izod and E. J. Laschinger (Abstractd)
Are We Becoming Too Automatic? Roger Price
Ventilation of Mines, W. Pile

Air Consumption and Maintenance Costs of Rock Drills, E. G. Izod and R. J. Laschinger (13 pp., 4 figs. *ps*). Of all the means for the transmission of power in general use for industrial purposes, compressed air is the most abused, or, one might perhaps better say, carelessly handled, and wasted. Since, at the present time, compressed air to a very large extent is directly purchased by many mines as power delivered at the shaft head at so much per unit, the subject of air consumption and economy in the use of air has again received further attention. As the air power used on the Rand is intended primarily for actuating rock drills, it is very important that the air consumption of these machines should be very thoroughly studied by engineers. Comparatively little is known about rock drills; if these machines had received a fraction of the thought and attention bestowed upon machine tools in the fitters', carpenters' and boiler-makers' shops, the history of the development of the rock drilling machine would have been a very different story and the machine itself would have attained a state of perfection and economy unknown today.

The mines under the control of the Central Mining and Investment Corporation, Limited, and the Rand Mines, Limited, purchase nearly the whole of their air power from the Rand Mines Power Supply Company, Limited. Against this consumption of air power, there is to be set the work done. Each mine keeps a record of the "machine shifts" worked underground by the rock drills of various makes and sizes and also a record of winches, pumps, etc., which are driven by compressed air. All these machines are then brought down to the standard rate of a 3¼-in. machine shift. This 3¼-in. machine shift standard represents the work that should normally be performed by a rock drill with a 3¼-in. cylinder working as usual during an 8-hour mining shift. With regard to the machine shifts actually worked in drilling rock, separate records are kept of stoping and development shifts on each mine showing the air consumption per individual shift.

It is well known that the amount of air consumed per development shift is greater than per stoping shift. By plotting the air consumption of each mine for each month per 3¼-in. machine shift in a position which corresponds to the ratio of development shifts to total shifts, points are obtained which show a mean line of air consumption and which indicate whether at any particular mine more or less air is being consumed than the average to be expected. With regard to mines which take more air than the mean mimimum as shown on the diagram, one must not at once jump to the conclusion that air is being wasted. On mines with wide stopes where deep holes are drilled, more air is used per machine shift and yet with greater economy in so far as breaking ore is concerned; hardness of rock, width of stope, footage drilled and other factors enter into the problem. At the same time a high air consumption when shown on the comparative record should form the cause of a serious investigation. Also, since the miners do not usually take the trouble and extra care to save air, and to see that all joints are tight and hoses in good repair, there is need for constant care and supervision. The fact that large savings in the air power bill of the mines may be effected by paying attention to this matter of air consumption is given by the following Table 11, which shows a progressive diminution of the air power required on the mines of the Central Mining-Rand Mines group for 1912.

TABLE 11 TOTAL DRILL SHIFTS, TOTAL AIR UNITS AND UNITS PER DRILL SHIFT DURING PERIOD JANUARY TO DECEMBER, 1912

Month	Equivalent 3¼-in. Machine Drill Shifts including Pumps and Winches	Total Air Units	Units per Drill Shift
January	73,926	12,018,587	163
February	69,887	11,072,207	158
March	78,887	12,555,015	159
April	75,980	11,272,770	148
May	81,548	11,919,934	146
June	73,839	11,287,577	153
July	82,252	11,561,971	141
August	81,161	11,333,228	140
September	75,581	10,832,301	143
October	80,510	11,339,470	141
November	79,862	11,037,958	138
December	78,545	10,813,549	138

The improvement as between January and December shows a saving of over one shilling per machine shift in the air power cost.

The method of assessing work done by the arbitrary standard of the 3¼-in. machine shift is no doubt somewhat crude, but it was devised as a beginning for making comparisons to suit present conditions on the Rand. Separate air meters should be permanently installed on each working level of a mine and at each point where air is used for specific services. This would enable the engineer to find out at once where air was being wasted or used in apparently excessive quantities. Strict investigation at particular points could then be carried out and leakage or waste hunted down to its source. Certain expenses would be incurred. If, however, one reflects on the elaborate organization dealing with the electric power on the mines it is certainly surprising that the air power is not attended to in the same way.

Whatever the make or type of drill, there is one point which is common to all and which deserves the closest attention of the mechanical engineer on the mine: that is the condition of the drill (mechanically considered) before it goes down into the mine, and the repairs and renewals which are made from time to time, especially in view of the fact that the rock drill has rough work to do, is roughly handled by persons who, in many cases, have no mechanical knowledge, and that it has to work under the severest conditions that test any machine and militate against economy over a prolonged period.

In this connection the author refers to the system of rock drill maintenance introduced some five or six years ago at the Village Main Reef Gold Mining Company, Limited. This system consists of bringing every drill regularly to the rock drill fitting shop, overhauling thoroughly in all its parts, and particularly in finishing up the cylinders with reamers, and grinding down the pistons to an accurate fit within a few thousandths of an inch, and thus standardizing cylinders and pistons. Besides this, a record is made of each machine in a book kept for the purpose, and when from the records it appears that the machine has been in the mine for longer than three months, that machine is brought to the surface for overhauling, whether the miner likes it or not. There is no doubt but that the enforcing of this system has given this mine its fine record on air consumption.

A short resumé of the result of these tests is given in Table 12, from which it will be seen that the state of repair of the machines on the various mines is reflected, first in the great difference in relative air consumption on the various mines, and, secondly, in the case of the last two tests, the difference on the same mine between the machines in ordinary state of repair and after having been newly repaired for the purpose of comparison. The important point about the overhauling of rock drills is in connection with the true bore of the cylinder and good fit of the piston. The points which these tests do prove is that a very neat fit of the piston is essential to economy in air consumption. Some may be of opinion that these close fits of the piston in the cylinder will cause trouble in practice, but the best answer to that is the fact that this close fit has not caused any trouble in some years' experience at the Village Main Reef Mine. The sticking of the piston is caused by front bushing being too tight or by a bent piston rod.

TABLE 12 RESULTS OF TESTS ON DRILLS

Mine	State of Repair of Drills	Cu. Ft. of Air per Min. of Drilling Time	Relative Consumption	Average Drill Speed, In. per Min.
Village Main Reef	Ordinary	103½	100	1.27
A	Ordinary	122	118	1.20
B	Ordinary	137	132	1.80
C	Ordinary	153	147	1.29
C	Newly repaired	120	116	1.30

In the early portion of 1912 investigations were made into the cost of operating machine drills, and figures were obtained of the cost of maintenance of drills and of the cost of air used for drilling. It has been shown that the air units per equivalent rock drill machine shift have decreased due to the attention to various details of the drills, leakages, etc.

PERSONAL NOTES

Henry M. Leland, a Manager of the Society and general manager of the Cadillac Motor Car Company of Detroit, is president this year of the Society of Automobile Engineers.

At the meeting in London on December 9 of the committee of the International Association for Testing Materials, the United States was represented by Dr. Richard Moldenke and Walter Wood, Members Am.Soc.M.E. The proceedings of the meeting have not been made public, but certain proposals representing the view of American and German producers are to be circulated among British makers of pig-iron, cast-iron pipe and miscellaneous iron castings, with a view to getting a consensus of opinion.

John Price Jackson, recently dean of the School of Electrical Engineering of Pennsylvania State College and now commissioner of the department of labor and industry at Harrisburg, has been chosen one of the five engineers constituting the State Engineers Commission which is to draft a code for the registration of engineers in the State of Pennsylvania.

T. Kennard Thomson, a member of the American Committee to celebrate the 100th Anniversary of Peace among English-speaking peoples, proposes as part of the celebration the establishing of an international park and forest along the Canadian border from Lake Superior to the Pacific Ocean, having a width of ten miles in both the United States and Canada. This would act as wind break, thus greatly benefiting the climate, and a large number of animals could be bred to advantage on this 30,000 square miles of part forest, lake and stream, so that by proper management the reservation could be made not only self-supporting but a profit producer as well. Mr. Thomson's work in civil engineering is well known and his scheme for building sea walls at the lower end of Manhattan to form a new neck of land, thus relieving the congestion which now exists in lower New York, recently attracted much attention.

Wm. N. Stevens has severed his connections with the John Simmons Company, New York, to become identified with the Stevens-Aylsworth Company, of the same city.

Arthur M. Crane, who was formerly with the New York Continental Jewell Filtration Company of New York, is now sales manager of the Permutit Company of New York.

Carr L. Glasgow, until recently district manager of Allis-Chalmers-Bullock, Ltd., Montreal, Canada, has entered the service of Fairbanks, Morse & Company, New York.

Henry C. Beckwith has accepted the position of district manager of the T. L. Smith Company, Chicago, Ill. Mr. Beckwith was formerly associated with the Constructors Equipment Company of Seattle, Wash.

Aimé L. G. Fritz, formerly connected with the Toronto Electric Light Company of Toronto, Canada, has become superintendent of construction for the London Electric Company, London, Canada.

L. H. Mesker has severed his connections with the United Engineering and Construction Company, Cleveland, Ohio, to enter the sales department of the Cleveland City Forge and Iron Company.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Announcement has been made of the plans for the new buildings of the Massachusetts Institute of Technology, to be erected on the Charles River in Cambridge, Mass. These plans have been developed by the architect, William W. Bosworth, following an extended preliminary engineering investigation of college buildings throughout the world, made by John R. Freeman, Past-President of the Society, who did this work as an interested alumnus of the Institute. When completed, the buildings will comprise one of the most imposing educational groups in America, the impressiveness of which will be enhanced by the location on the Charles River.

The library is the central feature, in front of which is a central court of immense size and on two sides of which are the main sections of the educational building. Unlike the plan usually followed in this country, of separate buildings for the different departments, there will be a single large building for this purpose, with wings and open courts.

The construction features of this building are based upon a unit system of bays, the floors of which are supported by the outside walls independent of the partitions, so that rooms can be made in any multiple of the basic unit desired, simply by removing the partitions. In a similar manner the structure can be added to by building additional bays of standard size. It will be of interest to engineers to say that there will be two and one-half acres of roof-lighted drafting rooms. The size of the undertaking is indicated by the fact that there will be begun a simultaneous construction of buildings whose capacity will reach about 15,000,000 cubic feet, and it is estimated that the main central court is sufficient in size to offer a resting place for ten of the largest vessels of the United States Navy. The department of mechanical engineering will contain 176,000 square feet, that of electrical engineering 50,000 square feet, of mining engineering 77,000 square feet, and of naval engineering 35,000 square feet.

Coincident with this announcement is another one to the effect that there will be coöperation in instruction between the engineering department of Harvard University and of Massachusetts Institute of Technology, whereby students and professors may interchange. Duplication in instruction in these neighboring institutions will be avoided and the Harvard students will have the advantage of the Technology laboratories.

STEVENS TECHNOLOGY MEETING

At a convention held at Stevens Institute of Technology on January 9 there was a general discussion of the relation of public utilities to the communities in which they operate. Among those who participated were Dr. Alex. C. Humphreys, President of Stevens Institute of Technology and Past-President of the Society, John W. Lieb, Jr., manager of the New York Edison Company, and James E. Sague, a member of the New York Public Service Commission, both members of the Society.

Dr. Humphreys in the course of his remarks referred to the control of public utilities by public service commissions, expressing his belief in a proper measure of control and regulation, but pointing out the necessity for broad knowledge and efficiency on the part of the commissioners. He said in part:

"Many of the questions which these commissions are called upon to determine require for their solution the high-

est engineering training and experience. And yet it is the exception when an engineer is appointed as a commissioner. The engineering profession is most often represented not as members of the board, but as employees of these boards, and so with no vote. Frequently the engineers so employed as subordinates to the commissioners are not qualified for an authoritative position in any of the companies over which they are thus given, indirectly it is true, a large measure of authority. I have held that on every one of these commissions the engineering profession should be adequately represented in the persons of men educated in the science of engineering and later trained in the hard school of experience, these men to be voting commissioners.

I by no means claim that because a man is an engineer he is thus necessarily qualified for membership on such a board, any more than a man is qualified to be a judge because he is a lawyer. Whether the commissioner is engineer, lawyer, accountant, or business man, he should be broadly trained and he should have had experience in the exercise of administrative functions."

Mr. Lieb outlined the broad powers vested in such commissions, the immense field which their activities cover, and emphasized again the necessity for a personelle of the highest order. "It must be obvious," he said, "that the presence of a technically educated and scientifically trained member on the commission should be of enormous assistance and value in its work, only second in importance to the presence of a representative of the legal profession. The professional politician, or 'statesman,' as he would prefer to be called, is likely to be strongly represented in the make-up of the commissions, but to find a representative of the engineering profession in the Commissioner's chair is, indeed, unusual and exceptional.

Our technical graduates should be trained and train themselves so that when they are called upon for the facts, or to present evidence or testimony in these cases that their presentation be clear, convincing, to the point, and delivered with the weight of authority. We should cultivate the habit of clear statement as well as clear thinking, and school ourselves in the facility of communicating technical information and expert testimony, so that it may be understood by the layman and that our arguments and presentation may create a favorable impression and carry due weight."

Mr. Sague followed with a most interesting account of the large problems with which commissions have to deal and the vast field which they must cover in their investigations in order to keep informed and to make intelligent investigations.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a meeting on January 14, F. L. Brewer, Jr. gave a talk on Stanley Steam Automobiles, in which he described the entire power plant and took up the advantages and disadvantages of steam in the automobile industry. Lantern slides were used in illustrating Mr. Brewer's remarks, and a discussion followed.

CARNEGIE INSTITUTE OF TECHNOLOGY

The regular meeting of the Carnegie Branch was held on December 17. Prof. J. C. Sproul gave a talk on Modern Automobile Practice in which he described the various types of automobile motors used in this country and in Europe, giving the relative merits of each and the results that have been obtained from them in testing. He also outlined the construction and working of the various differentials and axles that have been adopted in the best automobile and traction engine practice.

COLUMBIA UNIVERSITY

H. L. Gantt, Mem.Am.Soc.M.E., gave a lecture on the Relation between Employer and Employee before the Mechanical Engineering Society of Columbia University on January 9. He pointed out that the real problem which confronts the college graduate is human nature: how to deal with men. To obtain successful coöperation with the workman, the employer must cause the workman to have an interest in his work. This can be accomplished by setting a task for him to do, showing him how to do it, and paying a good wage. As the trained man can on the average do three times as much work as one who is untrained, these methods result in increased production and lowered wage costs.

CORNELL UNIVERSITY

Prof. F. R. Hutton, Honorary Secretary Am.Soc.M.E., gave a talk before the Sibley College Student Branch on December 16, on the Relation of the Draftsman to the Engineer, in which he dealt purely with the ethical side of the relationship.

On January 15 Mr. Henderschott, director of the New York Edison Schools and secretary of the Association of Corporation Schools, spoke of the present great interest in industrial instruction, and pointed out the need of commercial training in the public schools. He gave statistics showing that in a 300-day year, of eight hours a day, one workman was killed every four minutes and another injured every four seconds each year. This proportion is being reduced by welfare work, including safety devices, sanitation and instruction.

LEHIGH UNIVERSITY

On December 9 at a meeting of the Lehigh University Mechanical Engineering Society T. G. Shaffer read a paper on Transformers, which gave a short outline of the methods of construction and of testing in transformer practice. Prof. A. W. Klein, Mem.Am.Soc.M.E., also described his trip to Germany last summer to attend the meeting of the Verein deutscher Ingenieure.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At a meeting of the Mechanical Engineering Society of the Massachusetts Institute of Technology on December 31, Gorham Dana gave an interesting talk on the Requirements of the Underwriters for Fire Prevention. His remarks were illustrated by lantern slides.

OHIO STATE UNIVERSITY

The Student Branch of Ohio State University has held regular meetings during the term. On October 1 Prof. F. E. Sanborn, Mem.Am.Soc.M.E., gave an address on Technical Museums; on October 17 C. L. Newby spoke on the Transhipping of Cargoes on the Great Lakes; on November 8 Prof. F. W. Marquis, Jun.Am.Soc.M.E., read a paper on the Design and Construction of a Locomotive Testing Laboratory. On December 11 B. H. Smith gave an illustrated lecture on the Gas Producer, placing special emphasis on recent development, such as the static scrubber, etc.

PENNSYLVANIA STATE COLLEGE

The Pennsylvania State College Student Branch held a meeting on January 14 at which the following officers for the second semester were elected: A. L. Foell, chairman, C. F. Kennedy, vice-chairman, R. W. Hertzog, secretary, R. B. Rudy, treasurer. P. W. Barr presented a paper on

Resuscitation, and N. H. Slack a paper on the Advancement in Motor Car Design for 1914.

POLYTECHNIC INSTITUTE OF BROOKLYN

On January 10, Franklin Van Winkle, associate editor of Power, spoke before the Polytechnic Institute of Brooklyn Student Branch on Hydroelectric Development at Paterson, N. J. Much descriptive material was given, illustrated by lantern slides, which plainly showed how these plants were at present inadequate where natural power was used.

RENSSELAER POLYTECHNIC INSTITUTE

In celebration of the ninetieth birthday of Rensselaer Polytechnic Institute a dinner will be given on Friday evening, February 6, at the Hotel Biltmore, New York City, at which the guests of honor will be the presidents of the American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, and the Society of Naval Architects and Marine Engineers, and other distinguished engineers and representative men identified with engineering development. There will be addresses by men of national reputation, who can speak with authority upon the value of engineering service and upon the opportunities, responsibilities and obligations of engineers in this era of progress and development. The members of The American Society of Mechanical Engineers are invited to attend. E. N. Sanderson, Mem.Am.Soc.M.E., is chairman of the committee in charge.

PURDUE UNIVERSITY

The Purdue Student Section was addressed on January 14 by O. C. Berry, laboratory instructor in the School of Mechanical Engineering. Mr. Berry has spent several years in study and experiment with gas producers as applied to power uses, and took for his subject the General Development and Construction of Power Gas Producers.

LELAND STANFORD JUNIOR UNIVERSITY

The Stanford Mechanical Engineering Society is pursuing the plan of holding joint meetings with the student branch of the American Institute of Electrical Engineers, the Civil Engineering Society, and the Geology and Mining Society. On November 21, George M. Brill, Mem.Am.Soc. M.E., presented a paper on the Engineering of Manufacturing Plants, and on December 4, A. H. Babcock, chief electrical engineer of the Southern Pacific Company, spoke on the Electrification of the Tehachapi.

SYRACUSE UNIVERSITY

C. W. Chandler spoke at the meeting of the Syracuse University student branch on December 22, taking as his topic Locomotive Valve Gears. He described briefly the Stephenson link, radial gear, Baker motion, Marshall gear, and the Walsheart gear, explaining the last at some length.

UNIVERSITY OF ILLINOIS

At the meeting of the student branch of the University of Illinois on December 12, Professor Harding gave a talk on Linoleum Plants, Their Operation and Design. He spoke of the proper selection of the location of the plant and the actual operation of it. Numerous views of the machines used, some of which he had designed, were shown.

UNIVERSITY OF KANSAS

The University of Kansas Student Section held its fifth annual meeting on December 11, which is the date of the formation of the section. At the morning session, Dean Walker gave the greetings of the University, and three papers were presented: Compressed Air Equipment, by B. B. Brewster of the Sullivan Machine Company, St. Louis, Mo.; Survey of Alloy Steels, by Professor Whitaker of the department of metallurgy; and Producer Operating and Testing, by Prof. A. A. Potter, Mem.Am.Soc.M.E., of Kansas State Agricultural College. In the afternoon, papers were given on the Engineer of Today, by Louis Bendit of the Hope Engineering Company, St. Louis; Senior Inspection Trip, by W. J. Malcomson, senior student; Lost Motion, E. B. Black, of Worley & Black, Kansas City, Mo.; Oil Engines, F. L. Weakley of the De La Vergne Machine Company, Kansas City, Mo.; and Efficiency of Power Transmission through Universal Joints, by Earl Carson, senior student. A dinner was given in the evening at which Prof. F. H. Sibley, Mem.Am.Soc.M.E., acted as toastmaster, and brief remarks were made by Professor Walker, L. C. Angevine, Louis Bendit, Clyde Marris, A. H. Sluss and F. L. Weakley.

On January 8 several papers and reports were read, one on a big irrigation project now under way in the beet-sugar fields at Garden City, Kans., by S. Fairchild; one upon a new engine designed for the Wright aeroplane, by F. Hartman; and others upon the design of ice plants, by Malcolm McCune; and on Navigating Barges with Producer Gas Engines, by O. T. Potter.

UNIVERSITY OF MISSOURI

Dr. Charles Elwood gave a talk before the Missouri University student branch on December 15 on Sociology as Applied to Engineering, especially in the field of efficiency engineering and scientific management.

UNIVERSITY OF WISCONSIN

At the regular meeting of the student branch of the University of Wisconsin on January 8 the following officers were elected; M. A. Cook, chairman, J. A. Hinckley, vice-chairman, R. E. Maurer, secretary, R. S. Dewey, treasurer.

UNIVERSITY OF NEBRASKA

Prof. C. L. Dean gave an address before the University of Nebraska student section on January 14, on the Westinghouse Air Brake, in which he traced its development.

On December 17 E. Bignell, superintendent of the Lincoln division, C. B. & Q. R. R., and the inventor of a new pile, spoke before the University of Nebraska student section on the Hydraulic Sinking of Concrete Piles. He related his experiences with the Platte and Missouri rivers, which almost every year washed out a portion of their bridges, and the use of the concrete piles to prevent this. W. O. Forman, efficiency inspector at the Burlington shops, also gave a short explanation of how the piles are made, and C. H. Gerber, state engineer, spoke upon the old and new style of bridges for the shallow Nebraska rivers. Moving pictures of the handling and sinking of these piles were then shown. The meeting was the largest so far held at the University.

WASHINGTON UNIVERSITY

At the meeting of Washington University Student Branch on October 16 the following officers were elected: A. O. Schleiffarth, chairman, Oliver Mann, vice-chairman, W. Seigrist, treasurer, James A. Watkins, Jr., secretary.

On October 30 Walter Seigrist, senior student, read a paper on the Efficiency of Emery Wheels, based upon tests and experiments which he had made. A general discussion followed.

At the meeting of December 2, A. O. Schleiffarth, senior student, read a paper on Boiler Rules and Regulations, in which he compared in detail the requirements of the different states, cities and the United States steamboat service. Special attention was paid to the necessity of a universal boiler law.

The meeting of January 13 was a joint meeting with the student branch of the American Institute of Electrical Engineers. Hans Weichsel, chief engineer of the Wagner Electric Company of St. Louis, presented a paper on Electric Starters for Automobiles, which he illustrated with lantern slides showing various views of the starter and its construction.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

1223 Member holding patents on dispensing device and carbonating machine desires to come in contact with manufacturing house, who will place these patents on the market; inventions are original and highly thought of by engineers. Apply through the Society.

100 General manager and sales agent wanted for rivet and bolt business with increasing possibilities in the Middle West. Address P. O. Box 1974, Boston, Mass.

102 Two young technical graduates wanted in the maintenance department of New York concern.

105 High grade engineer, sales manager of mechanical experience and ability, technical education and able to direct advertising department and look after domestic and foreign sales of large shop with new equipment and employing 1500 men. Excellent opportunity and future for the right man.

106 Superintendent of plant and equipment in well established company having been in business 30 years manufacturing large quantities of small interchangeable parts, stampings, castings and screw machine parts; man with at least five years executive experience. Apply through the Society.

107 Concern marketing automatic machinery of interest to any trade shipping or packing granular products such as coffee, grain, soap powders, etc., desires to obtain agents to work on commission in the large cities of the United States. Applicants should state definitely what experience they have had with automatic packing machines and firms with which they have been connected. Apply through the Society.

110 Assistant time study man and rate demonstrator, who can operate machine tools and experienced in figuring time standards for manufacturing operations both by observation and experiment. Position pays $25 per week or if applicant has unusual experience in line of work and special rapidity and efficiency will pay more. Location Buffalo.

111 Only men of exceptional ability in design of new metal-working and electrical machinery will be considered; must be able to improve machines and tools now in use, to handle men, gain and hold their confidence and secure their best efforts. Preferably, but not necessarily, a college graduate, with knowledge of construction of motor-driven vehicles and their component parts. Employing company one of the largest in its field. Location middle west. Address C. B. R., 730 Citizens Building, Cleveland, Ohio.

MEN AVAILABLE

40 Position desired as plant manager, or supervisor of economical and efficient operation. Formerly associated in professional efficiency work with noted engineer. Later plant manager, director of economical operation all plants of corporation; left voluntarily to engage independently as efficiency engineer. Desires permanent relationship with large manufacturing organization. Opening salary, $4000 per annum.

41 Member, 36 years of age, graduate mechanical engineer, 15 years' broad and general experience in designing, estimating and constructing various types of mill buildings, factories, railway shops and power stations; thoroughly familiar with all kinds of building construction. At present employed as superintendent on a contract job.

42 Sales engineer, experienced in handling high-grade specialties in power transmission and machinery lines; known to machinery and supply trade of United States and Canada for past eight years.

43 Member, long experience with development and testing of a well-known make of gas engines, passing on the engineering points in hundreds of gas engine contracts and in charge of many difficult trouble cases. Applicant desires a new position with broader outlook. Would undertake steam or gas engine power plant design and operation.

44 General utility executive, technically educated as a mechanical engineer, who, under the titles of assistant vice-president and secretary, has served as a general utility man for well-known manufacturers of machinery; duties including sales, advertising, development of new ideas, pushing out work and general office management; seeks a responsible position where a wide engineering knowledge will be of value.

45 Member, technical graduate, mechanical and electrical engineer who has had broad experience in machinery design, development and manufacture, as designer, chief engineer, and works manager, seeks executive position with manufacturer of electrical or mechanical apparatus, as mining machinery. Reply through the Secretary.

46 Member, graduate mechanical engineer, patent expert, experienced in the design and manufacture of electrical machinery and apparatus and mining machinery; the development of methods and processes of manufacture; the handling materials and general industrial engineering, wishes to become associated with engineering firm having supplemental talent and experience. Reply through the Secretary.

47 Mechanical engineering graduate, three years shop, drafting and office experience. Desires position with future. Willing to start low; preferably commercial or executive work. Age 25; single; location immaterial. Good references.

48 Junior, B. S. and M. E., University of Wisconsin; five years experience in design and manufacture of marine and stationary gasolene and oil engines. Age 25. At present employed. A good proposition requiring ability and responsibility is desired.

49 Member, age 40, specialist in mechanical movements and contrivances, gearing and automatic machinery for special work, would like a position with manufacturing concern desiring a man who will make a study of their machinery and methods, suggest more efficient and economical ways of doing things, invent and design new machines or attachments, and in general improve the quality of the product and decrease costs through the introduction of better mechanical equipment. At present employed in similar capacity.

50 Member, age 40, nine years experience in the teaching of mechanism, descriptive geometry, drawing, and engineering mathematics; six years practice in mechanical engineering work; author of texts in descriptive geometry and mechanism, and articles in engineering journals, successful as teacher, lecturer and manager, desires position in university or technical school.

51 Mechanical engineer, holding managerial position, desires connection with manufacturing concern where executive and administrative ability may be coupled with technical training. Experience covers seven years in foreign and domestic sales. Advertising considered where above qualifications offer opportunity.

52 Member, 38 years of age, desires position as superintendent or factory foreman, practical machinist, ten years experience in charge of shops and departments; competent to organize; thoroughly familiar with all modern manufacturing methods and systems. Location immaterial. Best references.

53 Member, with broad experience in mechanical and structural steel engineering; having energy and business ability; invites correspondence with firms desiring representation in Minneapolis or St. Paul.

54 Member, graduate M. E., age 35, employed at salary of $4000, exceptionally successful in handling men, having broad experience in operating, service, maintenance, construction and design, desires position offering opportunity for wider field of activity than the present one.

55 Member, engineer, 34 years old, married, Englishman, having technical training and a fluent knowledge of the Russian and German languages, with experience in all classes of heavy and light tools, and all types of power plant machinery, wishes to represent in Russia a large American concern. Experience in the United States with the largest firms covers a period of 12 years and embraces purchasing, sales, operation and design.

56 Member, 34 years old, technically trained, for the last seven years in a responsible position with a large industrial concern; experience covers research work, operation, design and construction, desires to connect with a progressive industrial or public service company in the capacity of an engineer executive who can investigate and analyze conditions with the idea of developing and improving a property. Complete details and references upon application.

57 Technical graduate, age 40, thoroughly familiar with recent developments in by-product coke ovens; five years business experience as contracting engineer blast and open-hearth furnace and by-product coke oven construction, desires connection with concern contemplating work in this line.

58 Member; desires position as works manager or general superintendent. Long experience in manufacturing shoe machinery, typewriters, firearms, and automobiles. Experienced designer of production tools, systematizing methods, planning, laying out and routing work through shop, and organizing departments for manufacturing interchangeable parts.

59 Factory manager or superintendent. Experienced mechanic with executive ability, interchangeable manufacturer; high-grade work; low factory cost. No experiment, results assured. New England location preferred.

60 Junior member, graduate mechanical engineer, desires position as mechanical superintendent or engineer of construction, with manufacturing firm; six years experience with consulting engineers and industrial corporations, in design, construction and operation.

61 Member desires position as works manager, superintendent, or engineer; has made time studies a specialty. Best references.

62 Student member, graduate mechanical engineer, one year's experience in construction and valuation of railroads and six months in large manufactory, would like position where permanence and advancement may be looked forward to. At present employed.

63 Member, age 36, technical graduate, ten years commercial experience and five years teaching, now lecturing on heat engineering and in charge of mechanical engineering laboratory in post-graduate department of eastern school, wishes to change. Prefers associate professorship in an institution which has a man to handle machine design and applied mechanics, that he may continue his present specialization; but has had charge of department of mechanical engineering, and can carry whole work if desired.

64 Member, experienced as general or business manager, mechanical engineer, salesman and executive, desires position with manufacturing establishment or branch house; salary $3000.

65 Junior member, age 28, technical graduate in mechanical engineering, experienced in power plant development and general mill engineering, wishes to locate with some progressive company as assistant mechanical engineer or similar capacity.

66 Member; graduate mechanical engineer with broad experience in machine shop, drafting room, erecting and operating; has designed a number of successful internal-combustion engines from 40 to 100 h.p., conducted large and important tests, acted as consulting engineer and in a manufacturing business as one of the proprietors. Desires position as shop or sales manager of a manufacturing company.

67 Associate-Member with technical education, supplemented by four years of sound power plant experience, desires to get in touch with a firm handling a power plant line and having an opening as representative or assistant sales manager.

68 Student member who will graduate June 1914 desires position with good future; four years experience previous to entering College; ambitious and energetic; best references; knowledge of several languages.

69 Junior member, age 27, graduate mechanical engineer, five years experience in automobile manufacture and design, for the last two and one-half years in charge of experimental department in one of the leading automobile factories building a high priced car. At present employed.

70 Junior; graduate mechanical engineer; ten years practical experience in mechanical and electrical lines, erecting power house equipment; master mechanic of large factory; past four years with a sugar company as chief engineer in charge of designing, construction, maintenance and operation of numerous pumping plants and irrigation systems, pipe and power lines, superintendent of city light and water systems; accustomed to figuring costs and purchasing material. Executive ability and excellent references. Employed at present. Address: Box 106, Hamilton City, Cal.

71 Junior; age 31; technical graduate in mechanical and electrical engineering desires position of responsibility with future. Ten years experience in design, superintendence of construction, operation of substations pole and tower lines, as well as testing electrical machinery. Also experienced in high voltage construction and operation. Salary, moderate.

72 Member experienced in successful production and sale of mechanical equipment, seeks association with a concern in need of such personal services where the advantages will prove mutual.

73 Junior member with experience as chief engineer, superintendent of steam turbine power house construction and operation is open for engagement; a specialist in all the modern boiler room economies. Age 32, married, eastern location preferred, but will go anywhere.

74 Mechanical engineer, thoroughly experienced in design of precision machine tools, heavy hydraulic hoisting and pumping machinery; can handle men and get results; familiar with modern methods, and operation of alternating and direct current apparatus.

75 Member, university graduate in mechanical engineering. 17 years practical experience since graduation. Age 40. Specialist in design, construction and operation of all types of dredges and auxiliary plant. Seven years in sole charge of important dredging undertakings. Wishes to hear of opening as mechanical engineer or other responsible position, preferably with dredging firm. Highest references.

76 Member, graduate mechanical engineer Worcester Polytechnic Institute, two years law study, several years experience in charge of experimental engineering; six years as Chicago manager for Pratt and Whitney Company; several years experience in manufacturing as superintendent, works manager, and general manager. Is desirous of a permanent connection with a reliable enterprise either as general manager, works manager, or advisory and reorganizing engineer.

77 Member, technical, 36 years of age, 14 years' experience in the design, erection and maintenance of steam power plants and manufacturing plants, desires position as construction engineer or mechanical superintendent with some large manufacturing plant. At present employed as resident engineer.

78 Managing sales engineer, open for contract to build up business with New York as headquarters. Have specialized in power plant equipment, contractors and conveying machinery. Practical shop and field experience; diplomatic and progressive.

79 Junior member, Stevens graduate, M. E., aged 28, at present employed, desires position as mechanical engineer. Has had some years' experience in shop work, drafting room

designs and engineering practice with firm designing and building refuse incinerators and steam power plant equipment.

80 Member, at present employed, 18 years' varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of large industrial plants and equipment, systematizing of shops and processes along the lines of scientific management and efficiency, testing and general plant engineering; accustomed to handling men, drawing up contracts, purchasing equipment and material, appraising properties; desires to become identified with manufacturing or industrial plant of prominence in administrative or executive position of responsibility in which his experience may be of value. Best of references.

81 Mechanical engineer, technical graduate, age 30, desires responsible position. Thorough knowledge of all types of pumps and pumping machinery, gasolene and oil engines, steam engines, and sugar house machinery. Drawing room, erection room and engineering department experience in large pump manufacturing company. Sugar plantation work in Mexico and sales engineer in Brazil. Natural ability in handling men and getting results. Best of references.

82 Associate-Member, graduate M. E., 29 years old, would like position with reliable concern. Experienced in design and construction of power and industrial plants including surveying and some operation. Would not object to some drafting work; sales proposition would be considered. Salary according to position and location. Location no object.

83 Member, technical graduate, desires position as works manager or general superintendent, experienced in foundry and machine shops, a good executive and manager of men.

84 Member, M. I. T. graduate, experienced as office, advertising and sales manager wants position with growing concern. A congenial, permanent and eventually profitable affiliation more important than initial salary.

85 Member, desires position either as superintendent, designer or sales engineer, New York City or vicinity; has a clear record for past work.

86 Graduate mechanical engineer, twelve years' practical experience; has made specialty of experimental research work in compressed air machinery; also experienced in structural work, boilers, hydraulics and magazine editorship on machine shop practice. Would like position as college instructor in mechanical engineering; especially trained and fitted for laboratory work.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

Aeronautics in the Army. Hearings before the Committee on Military Affairs. *Washington, 1913.* Gift of U. S. army.

American Association of Commerce and Trade, Berlin. Report of 11th annual general meeting, 1913. Gift of association.

American Association of Public Accountants. Yearbook 1912-1913. *New York, Ronald Press Co., 1913.*

American Ceramic Society. Trans. vol. 15. *Columbus, 1913.* Gift of society.

The American Society of Mechanical Engineers. Index to Trans. vols. 1-34; also the Journal, January-November, 1913. (Manuscript.)

American Woods. R. B. Hough, pt. 13. *Lowville, 1913.*

Arcade Underground Railway. Report of E. L. Viele.

Baumaterialienkunde. vols. 1-6. 8-12. *Stuttgart, 1896-1901, 1903-1907.*

Centralized Control System and Power Station Switchboards for the Panama Canal, E. M. Hewlett. From Switchboard News, January, 1914. Schenectady, 1914. Gift of E. M. Hewlett.

Chemische Technologie der Gespinstfasern, Karl Stirm. *Berlin, 1913.*

Connecticut. Bureau of Labor Statistics. Labor laws and directory of labor organizations of Connecticut, 1913. *Hartford, 1913.*

———Bul. no. 1. Workmen's Compensation. *1913.* Gift of bureau.

Expose of the Facts Concerning the Proposed Elevated Patent Railway Enterprise in the City of New York, 1866. *New York, 1866.*

Flugzeug Modellbau, P. L. Bigenwald. From Bibliothek für Luftschiffahrt und Flugtechnik, vol. 12. *Berlin, 1914.*

Fowler's Mechanical Engineer's Pocket Book, 1914. Edited by W. H. Fowler. ed. 16. *Manchester, 1914.*

Fowler's Mechanics' and Machinists' Pocket Book and Diary, 1914. Edited by W. H. Fowler, ed. 6. *Manchester, 1914.*

These very cheap little books, containing about 550 and 450 pages respectively, and selling for 40 cents and 12 cents, are full of practical data and tables. They must have wide use to be sold so cheaply.

Die geistigen Mittel des technischen Fortschrittes in den Vereinigten Staaten von America, Conrad Matschoss. *Berlin, 1913.*

Gyroscope, F. J. B. Cordeiro. *New York, 1913.*

Les Idées Modernes sur la Constitution de la Matière. Conférences faites en 1912. From Société Française de Physique. *Paris, 1913.*

Indiana Engineering Society. 33d annual report, 1913. *Indianapolis, 1913. Gift of society.*

Industrial Chemistry for Engineering Students, H. K. Benson. *New York, The Macmillan Co., 1913.*

This college text-book has one unusual feature which commends it to a librarian. Each chapter has appended an extensive bibliography. This leads one to suspect that the author, who is a professor of industrial chemistry in the University of Washington, requires his students to examine the literature of each subject, a plan too seldom followed in technical schools.

International Congress on Hygiene and Demography (15). Trans. vols. 2 and 3, pts. 1-2; vol. 4. *Washington, 1913.*

Kontrolle der Malzerei und Brauerei Arbeitsmaschinen, G. Jakob. From Oldenbourgs Technische Handbibliothek, vol. 19. *München, 1913.*

Die Kugellager und ihre Verwendung im Maschinenbau, W. Ahrens. From Einzelkonstruktionen aus dem Maschinenbau, pt. 4. *Berlin, 1913.*

Laboratory Engineering, H. G. Taylor. *London, 1913.*

Laying Out for Boiler Makers and Sheet Metal Workers. ed. 2. *New York, 1913.*

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Carnegie Inst. of Tech.	Oct 14, 1913	W. Trinks	J. B. Patterson	W. M. Sheldon 226 Meyran Ave., Pittsburgh, Pa.
Case School of Applied Science	Feb 14, 1913	F. H. Vose	H. C. Mummert	J. B. Whitacre Case School of Applied Science, Cleveland, O.
Columbia Univ.	Nov 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen Hartly Hall, Columbia Univ., N. Y.
Cornell Univ.	Dec 4, 1908	R. C. Carpenter	J. G. Miller	D. S. Wegg, Jr. Telluride Asso., Ithaca, N. Y.
Lehigh Univ.	June 2, 1911	P. B. de Schweinitz	W. C. Owen	T. G. Shaffer Lehigh Univ., South Bethlehem, Pa.
Leland Stanford Jr. Univ.	Mar 9, 1909	W. F. Durand	C. P. Campbell	B. M. Green 510 Walnut Ave., Redlands, Cal.
Mass. Inst. of Tech.	Nov 9, 1909	E. F. Miller	H. W. Treat	L. L. Downing 30 Bowdoin St., Cambridge, Mass.
New York Univ.	Nov 9, 1909	C. E. Houghton		
Ohio State Univ.	Jan 10, 1911	Wm. T. Magruder	R. M. Wagner	C. L. Newby 1425 Hunter Ave., Columbus, O.
Penn. State College	Nov 9, 1909	J. P. Jackson	A. L. Foell	R. W. Hertzog Penn. State College, State College, Pa.
Poly. Inst. of Brooklyn	Mar 9, 1909	W. D. Ennis	A. A. Bielek	H. Sand Poly. Inst. of Broooklyn, Brooklyn, N. Y.
Purdue Univ.	Mar 9, 1909	G. A. Young	S. A. Peck	T. S. Tulein Purdue Univ., West Lafayette, Ind.
Rensselaer Poly. Inst.	Dec 9, 1910	A. M. Greene, Jr.	F. E. McMullen	R. L. Manier Y. M. C. A., Troy, N. Y.
State Univ. of Iowa	Apr 11, 1913	R. S. Wilbur	F. H. Guldner	C. S. Thompson 935 E. College St., Iowa City, Ia.
State Univ. of Kentucky	Jan 10, 1911	F. P. Anderson	H. G. Strong	R. T. Thornton R. R. 1., Lexington, Ky.
Stevens Inst. of Tech.	Dec 4, 1908	Alex. C. Humphreys	L. F. Bayer	C. H. Colvin Stevens Inst. of Tech., Hoboken, N. J.
Syracuse Univ.	Dec 3, 1911	W. E. Ninde	G. T. Parsons	W. J. Campbell 303 Waverly Ave., Syracuse, N. Y.
Univ. of Arkansas	Apr 12, 1910	B. N. Wilson	M. McGill	C. Bethel Univ. of Ark., Fayetteville, Ark.
Univ. of California	Feb 13, 1912	Joseph N. LeConte	R. Guillon	P. H. Landon Univ. of Cal., Berkeley, Cal.
Univ. of Cincinnati	Nov 9, 1909	J. T. Faig	A. O. Hurxthal	E. A. Oster 1065 Wade St., Cincinnati, O.
Univ. of Illinois	Nov 9, 1909	W. F. M. Goss	A. H. Aagaard	H. E. Austin Univ. of Illinois, Urbana, Ill.
Univ. of Kansas	Mar 9, 1909	F. H. Sibley	L. C. Angevine	H. L. Newby 1501 Rhode Island St., Lawrence, Kan.
Univ. of Maine	Feb 8, 1910	Arthur C. Jewett	E. E. Fowler	A. B. Hayes S. A. E. House, Orono, Me.
Univ. of Missouri	Dec 7, 1909	H. Wade Hibbard	R. Runge	L. L. Leach Y. M. C. A. Bldg., Columbia, Mo.
Univ. of Minnesota	May 12, 1913	A. J. Flather	A. Buenger	J. A. Colvin 629 15th Ave., S. E. Minneapolis, Minn.
Univ. of Nebraska	Dec 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh Sta. A. Box 1164, Lincoln, Neb.
Univ. of Wisconsin	Nov 9, 1909	H. J. Thorkelson	M. A. Cook	R. E. Maurer 167 Prospect Ave., Madison, Wis.
Washington Univ.	Mar 10, 1911	E. L. Ohle	A. O. Schleiffarth	J. A. Watkins, Jr. Washington University, St. Louis, Mo.
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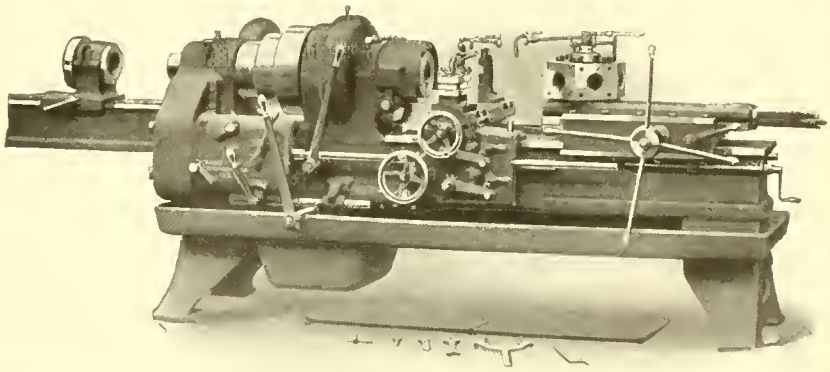

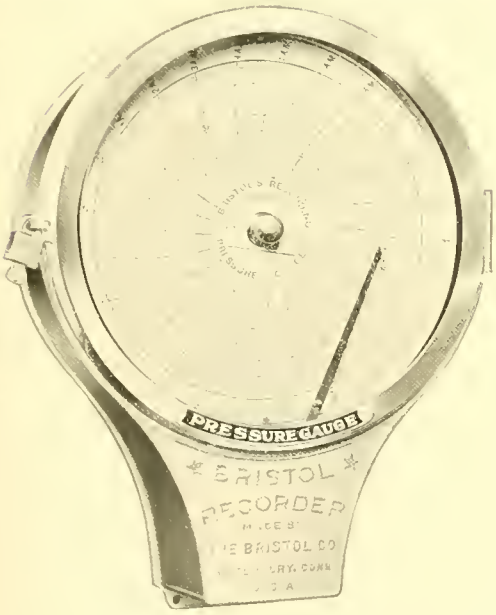

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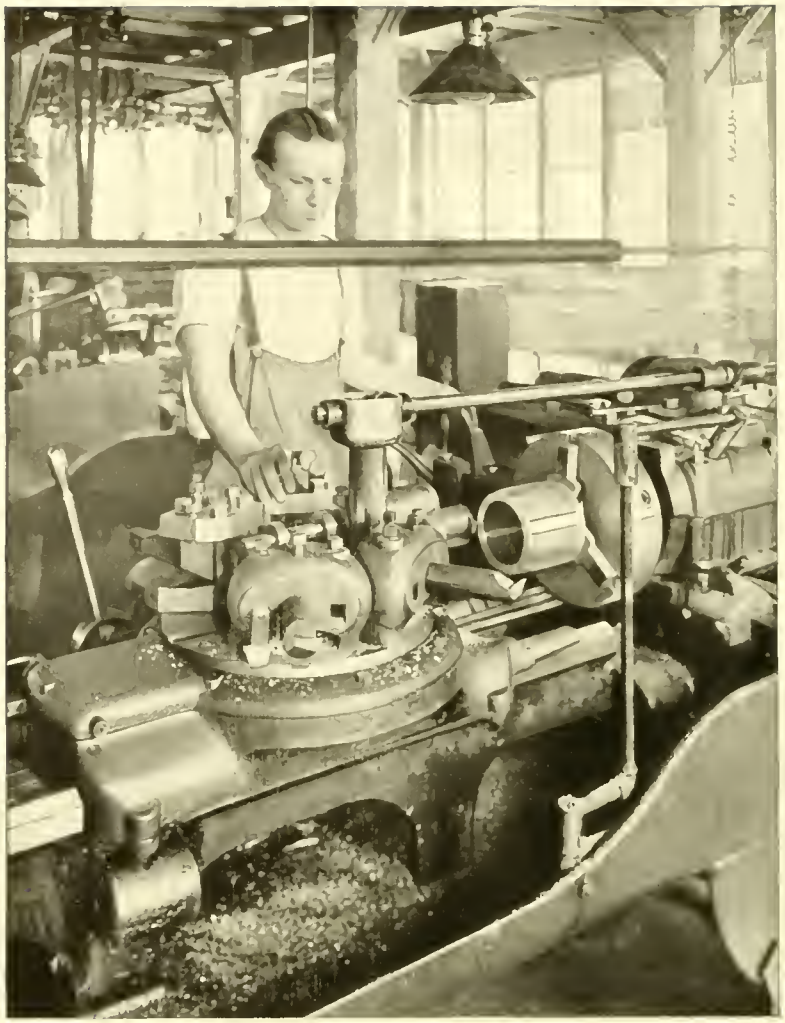

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is one of the secrets of the Flat Turret Lathe. It was a strong feature of the original bar machine back in 1890; it is true to-day of the latest design, whether used on bar or chucking work.

The machine shown is doing chucking work. The turret is gibbed at its outer edge to the slide; the locking pin is directly under the holder being used; the turret slide is gibbed directly to the bed, without the intervention of a cross slide—thanks to the cross sliding head.

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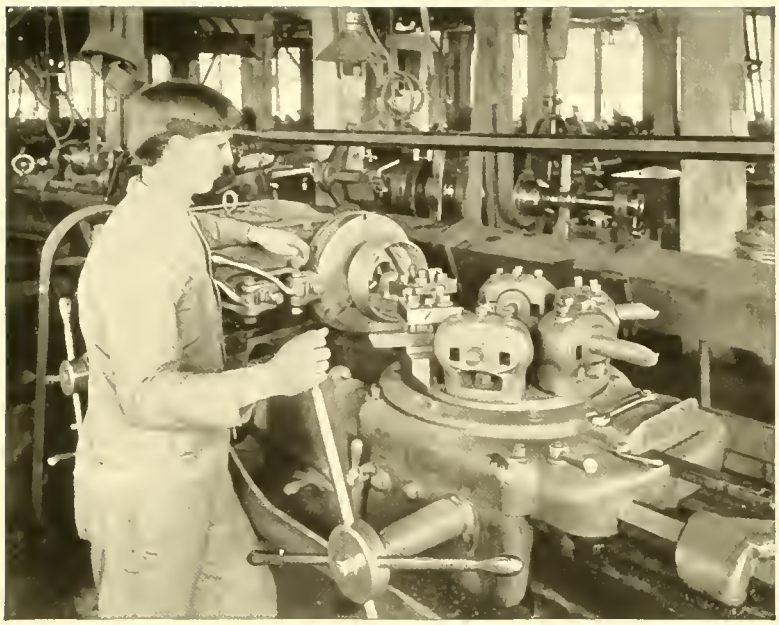

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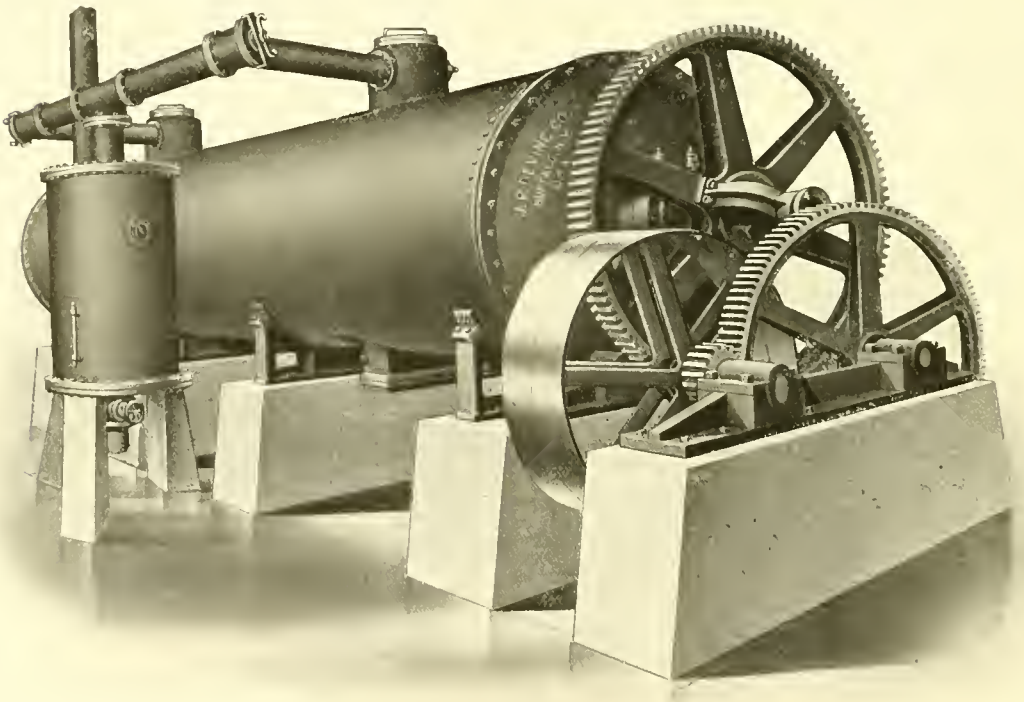

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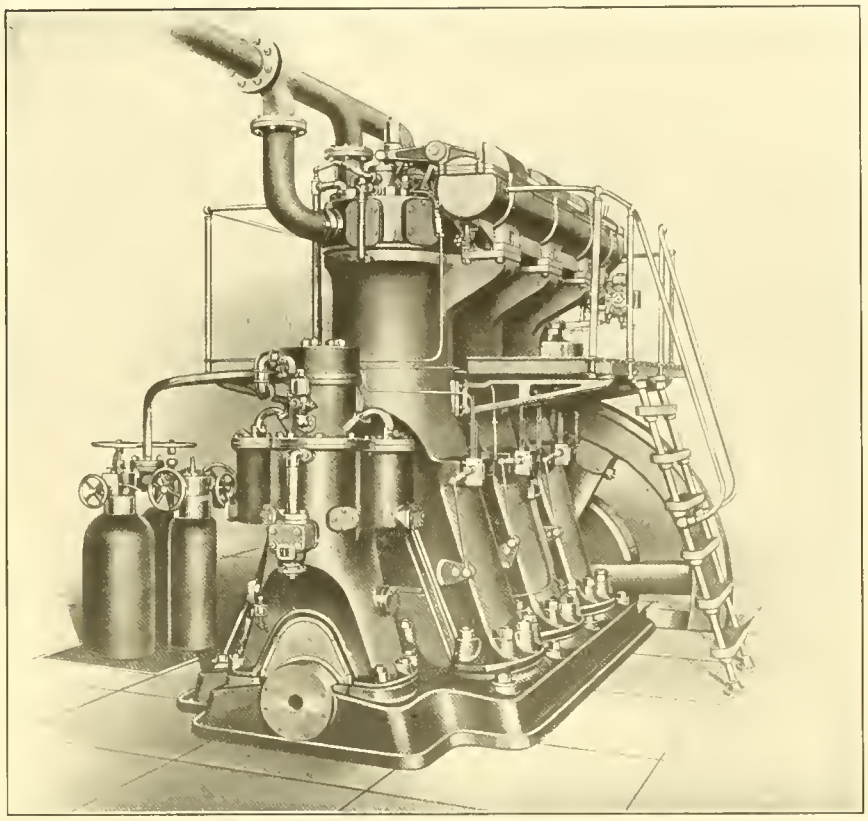

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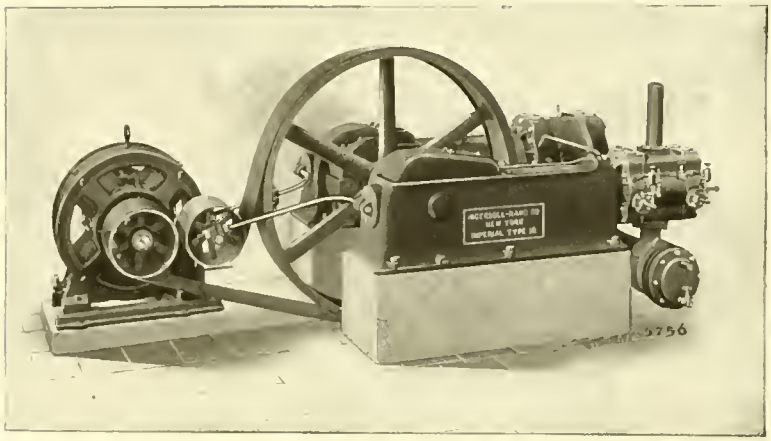

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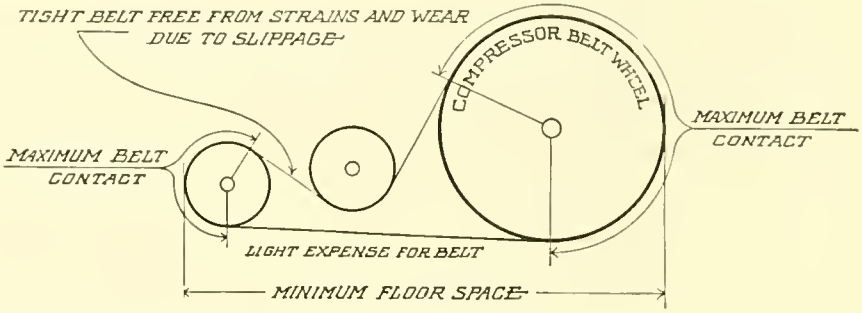
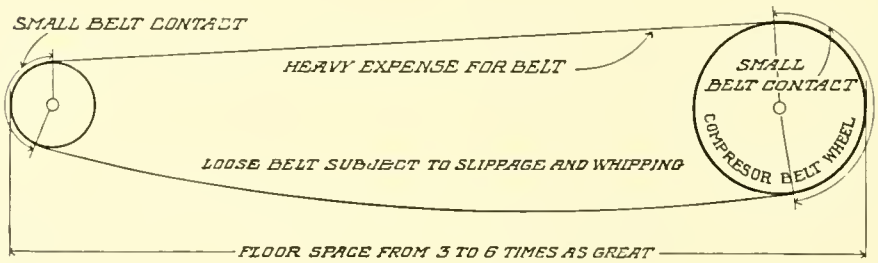


"Imperial" Short Belt Drive



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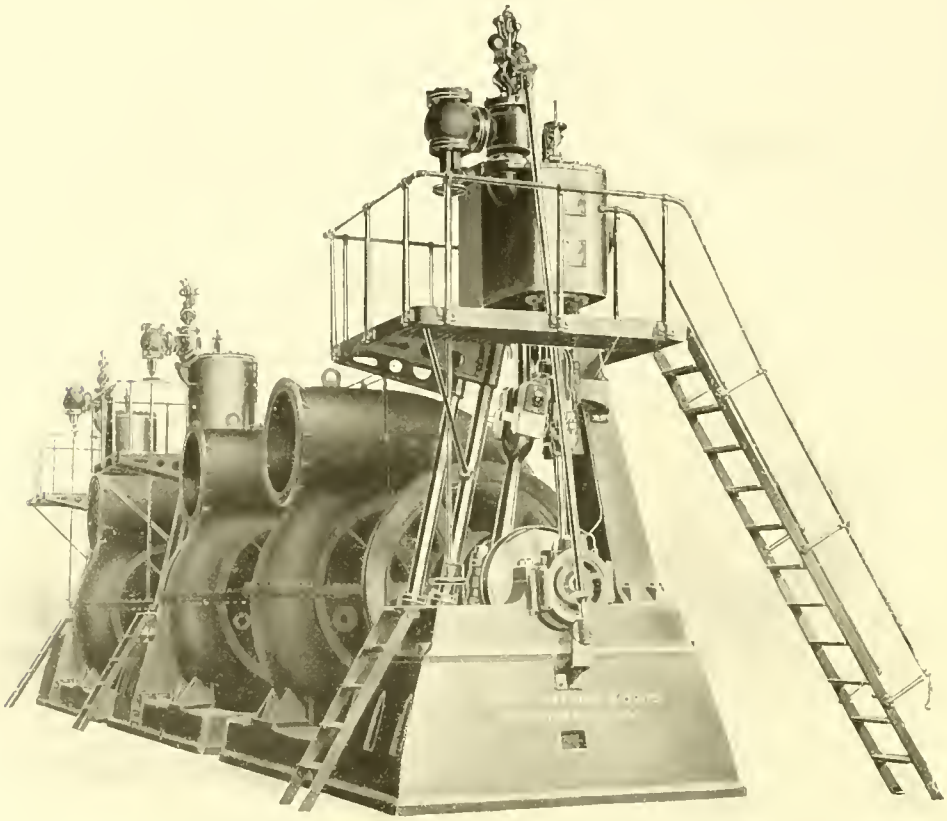

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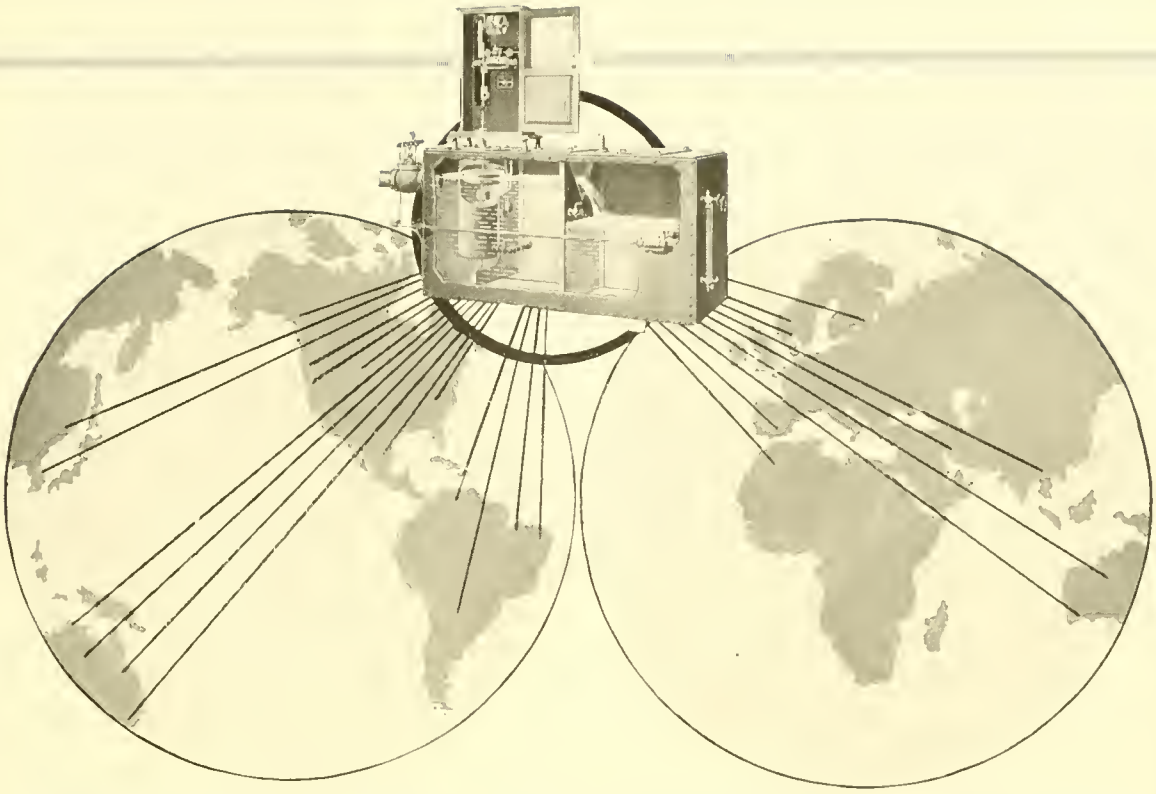

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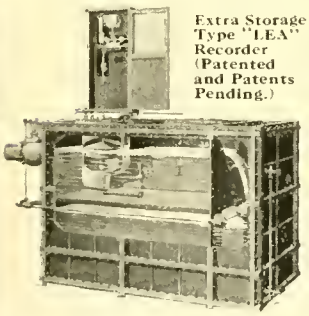

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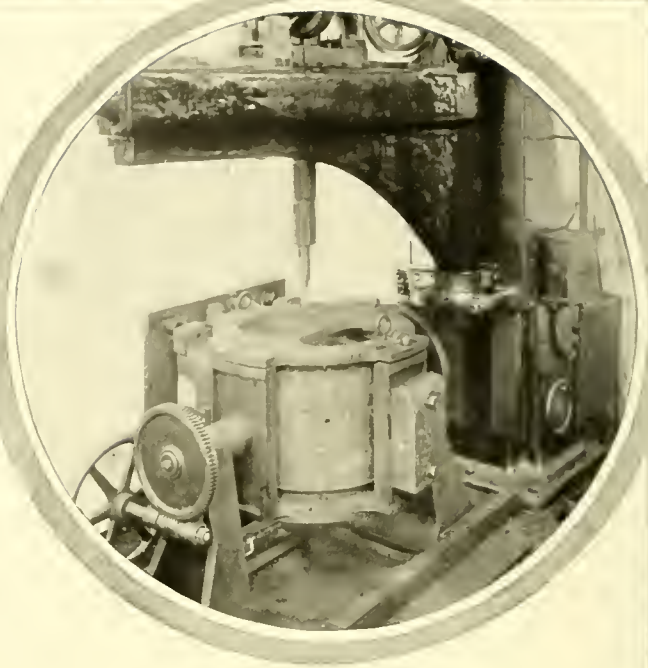

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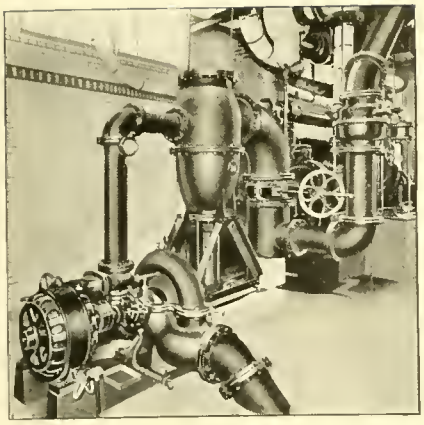

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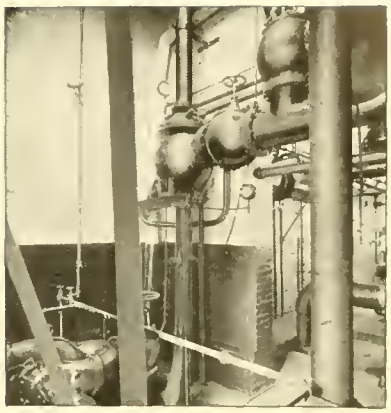

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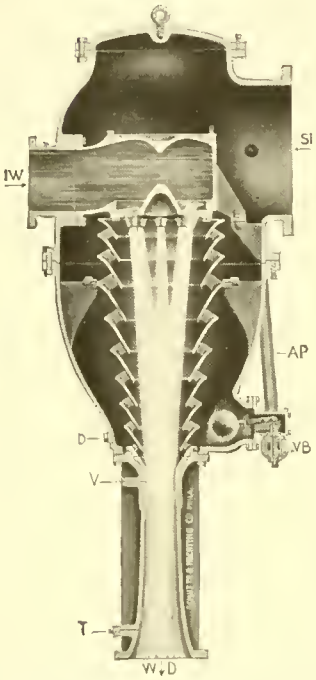

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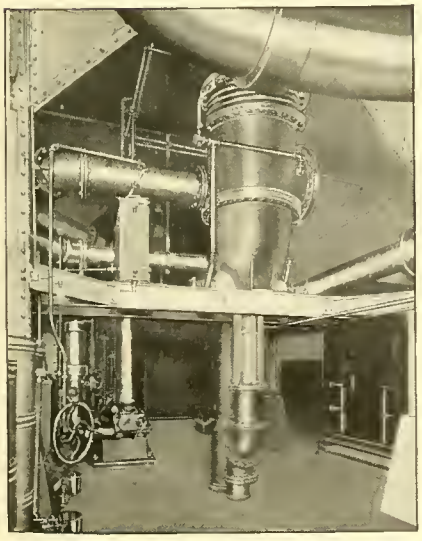

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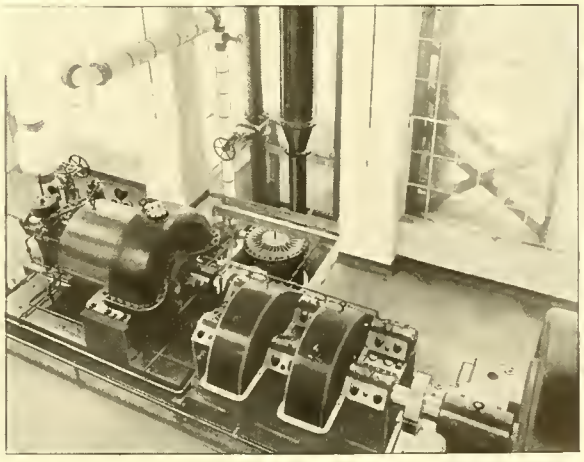

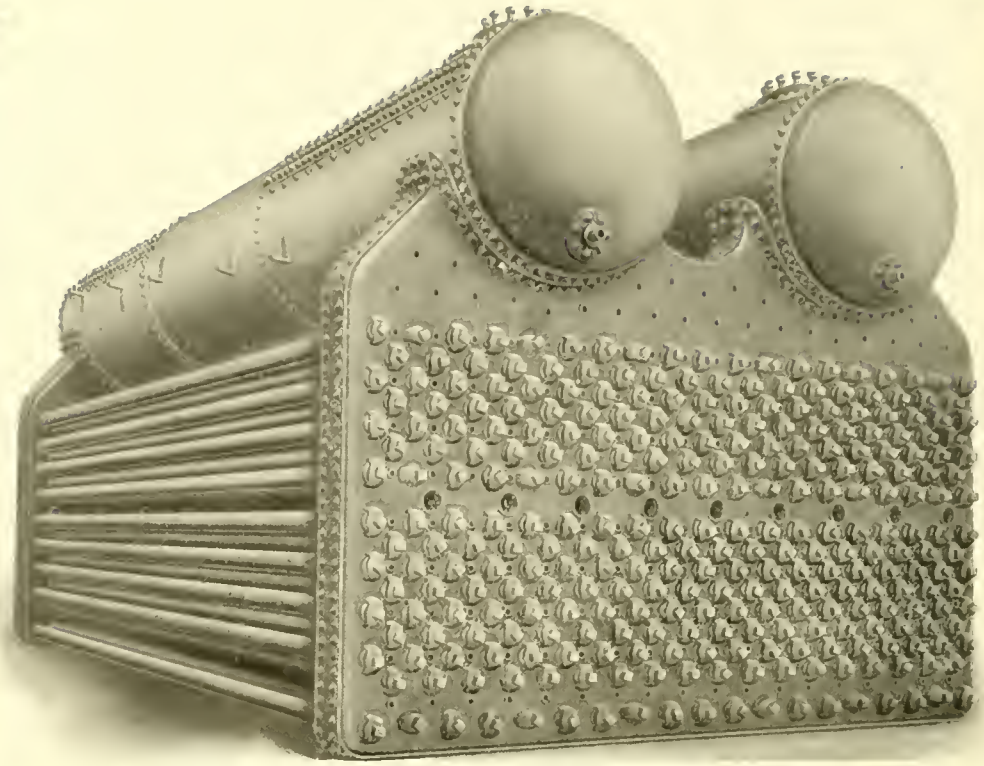

A typical large two-pass Heine Boiler; attention is drawn to the compact arrangement of tubes as indicated by the spacing of the handhole plates on the front water leg.

LARGE
Heine Boilers

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These boilers are built in all large sizes and have the following important features:

(1) Heine Waterlegs, which give large area for the circulation of water and steam, and therefore **high capacity.**

(2) Two horizontal passes, giving a very long path for the travel of the hot gases over the heating surface, and therefore **efficient heat absorption.**

(3) A **small draft drop** through the boiler, because of the few number of turns and the flow parallel to the tubes.

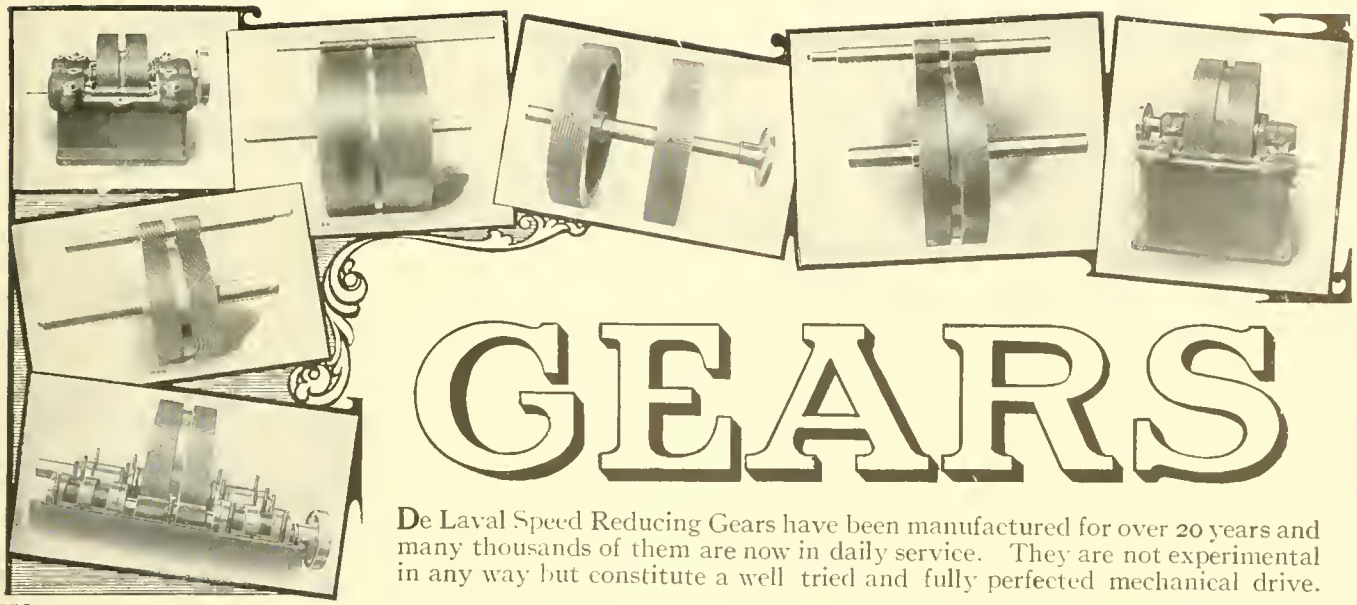
(4) Compact arrangement of heating surface, giving **minimum of floor space and head room** per boiler horse power.

Beside the above features, these Heine Boilers retain all the fundamental advantages of the Heine design, such as **smokelessness** and **efficient combustion,** ease of repairs and accessibility for cleaning and inspection and a high quality of construction down to the last rivet.

Send for our booklets "Boiler Logic," "The Space Occupied by Water Tube Boilers," and if interested in superheaters, our booklet "Superheating."

HEINE SAFETY BOILER CO.

2465 Marcus Ave. **ST. LOUIS, MO.**



GEARS

De Laval Speed Reducing Gears have been manufactured for over 20 years and many thousands of them are now in daily service. They are not experimental in any way but constitute a well tried and fully perfected mechanical drive.

We are equipped to manufacture De Laval Gears in all sizes and can especially recommend our heavy, slow-speed gears for use in the most trying situations, as driving condenser circulating pumps, rolling mills, centrifugal pumps for heavy water works service, etc.

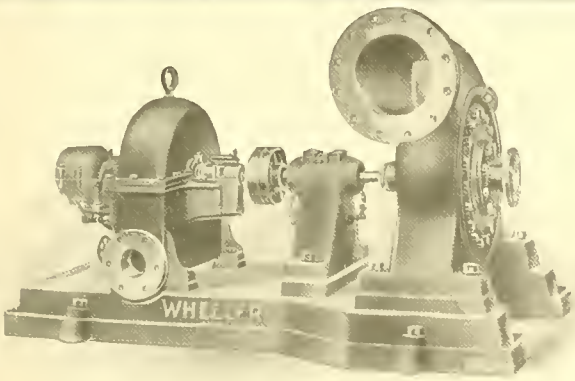
De Laval Speed Reducing Gears are employed in connection with De Laval Single-stage, Velocity-stage and Pressure-stage Turbines for driving direct current generators, centrifugal fans and pumps, rope and belt drive, and for supplying power to all kinds of moderate or slow speed machinery.

State what class of work you are interested in and we shall be pleased to send our Treatise "C58."

DE LAVAL
Steam Turbine Co.

Trenton **New Jersey**

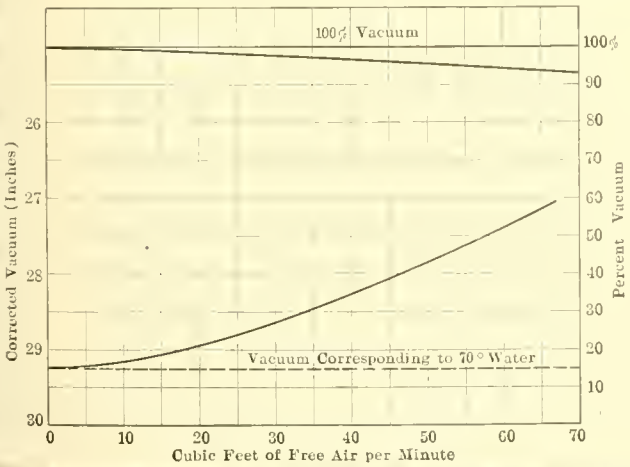
119



99% Vacuum With The Wheeler
Turbo Air Pump

A WHEELER TURBO AIR PUMP recently tested showed the following results with hurling water at 70°:

100% vacuum on a closed air suction,
99.7% with 5 cu. ft. free air per minute,
99.4% with 10 cubic feet of free air per minute,
And 99% with 20 cubic feet of free air per minute.



CONSIDER THESE FIGURES

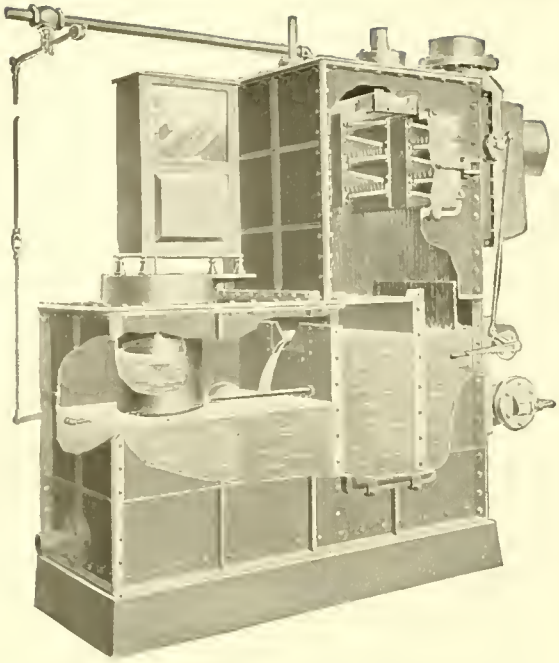
The normal air leakage of a large turbine and condenser is only 5 to 10 cubic feet of free air per minute, which the pump will handle at vacuums above 99%.

This means that you can maintain at the turbine exhaust, vacuums of 28½ to 29 inches in the Summer and 29½ inches and higher in the Winter, depending upon the amount of circulating water pumped.

If interested in Turbo Air Pumps, ask for our new Bulletin 111; in surface condensers, ask for our new Bulletin 106-A; in high vacuum jet condensers, Bulletin 107; in cooling towers, Bulletins 104 and 109.

WHEELER
CONDENSER & ENGINEERING CO.
CARTERET, NEW JERSEY.

110



Interior View of Cochrane Metering Heater

THE COCHRANE METERING HEATER

is a combined open feed water heater and hot water meter, a V-notch weir being enclosed within the heater structure, and the settling chamber of the heater being utilized as the still water chamber required by the V-notch. This arrangement enables you to measure the water at any temperature corresponding to the back pressure and avoid the escape of vapor and heat that is inevitable where water is measured by dumping buckets or by weirs in open tanks. It also secures greater accuracy and legibility of records than is possible with Pitot tubes or Venturi meters installed in the boiler feed line.

Our patents cover the unitary arrangement, also the operation of independent meters connected up with open feed water heaters in such manner as to realize the advantages possessed by the Cochrane Metering Heater. This enables you to convert any open feed water heater into an accurate and efficient meter at comparatively small expense.

Where closed heaters are installed, the Cochrane combined Independent Meter and Hot Well serves also as an automatic make-up water regulator and receiver for returns, and if the closed heater be protected by an oil separator so that the condensate may be led back to the metering hot well, gives most of the advantages of an open feed water heater except compactness and simplicity.

Send for our pamphlets, "*Precision in Measuring Water*" and "*Hot Water Meters and Their Practical Application*"

Harrison Safety Boiler Works

3199 N. 17th Street PHILADELPHIA, PA.

How To Get DRAFT For Nothing

A CHIMNEY implies a large first cost, imposing heavy annual charges upon the steam plant in the shape of interest on the money invested and the amounts that must be charged off annually for obsolescence and depreciation. You may wish to move the plant, or the plant may outgrow the chimney, in which case it becomes a total loss.

As for operating costs you may say that the chimney costs nothing to operate, but to operate properly, it must receive gases at about 500° F. As each 20° temperature in the flue gases represents about 1% of fuel, this represents a waste of 10% of fuel as compared with gases at 300° F.

Perhaps you say that this 10% would be wasted in any case.

Not so, however, if a Green's Economizer be installed in connection with the Green's Mechanical Draft Fan. With the combination the gases can be sent to the chimney at 300° F., with all the draft you want under all conditions and burning any grade of fuel. **The heat recovered by the Economizer will pay all charges, both fixed and operating, upon both Economizer and Fan, that is, you will get the draft for nothing.**

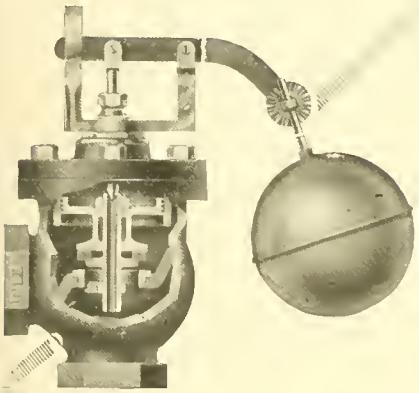
To obtain the most satisfactory results, put in a fan of first class construction and ample size, such as we recommend and build.

For the latest ideas on the "Economical Operation of Steam Boiler Plants," send for our Booklet M. E. 140.

The Green Fuel Economizer Co.

Matteawan, N. Y.

A Good Float Valve to Own



A piston, operating in a cylinder, that is packed with a leather crimp to prevent leakage is not a desirable construction for an automatic float valve. The packing causes friction and is short lived. That means unsatisfactory operation and expensive maintenance.

The Davis Improved Float Valve

has an inner valve that is not packed in any way. It is operated entirely by pressure. The top member fits the cylinder loosely so the inlet pressure can leak by and accumulate above the valve. The stem which is directly attached to the float, forms an auxiliary valve that controls the action of the disc.

This valve makes an ideal automatic control for your water supply. It will always work properly without sticking. Its maximum cost for maintenance will be the few cents that you may have to spend sometime for a new renewable Jenkins type of disc. Let us send you a descriptive folder and quote on the float valves you need at this time.

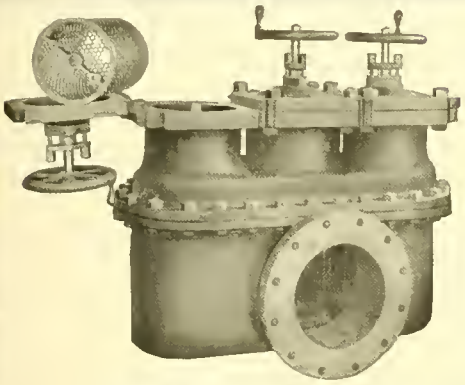
—it will not stick,
—will not leak,
—has renewable disc and seat,
—has no leather cup, packing,
—is operated entirely by pressure,
—has full pipe area,
—is strong and well proportioned,
—may be used as Balanced Valve,
—is made in globe and angle patterns.

G. M. Davis Regulator Co.

Established 1875

439 Milwaukee Ave. Chicago

New York, 123 Liberty St. Pittsburgh, 1st Natl. Bk. Bldg. St. Louis, 735 S. Fourth St.
Philadelphia, 2528 N. America St. Boston, 70 High St. San Francisco, Rialto Bldg.

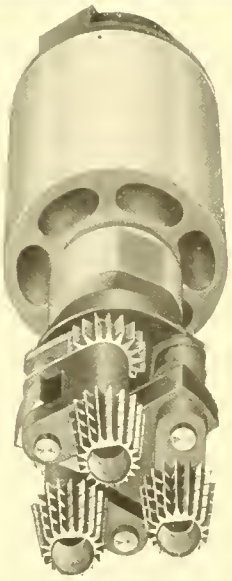


Lagonda Multiple Water Strainer

Appliances You Need

Lagonda Multiple Water Strainers remove sticks, leaves, fish, etc., from power plant intake lines. Protect pumps, condensers and boilers from damage. Can be cleaned while in operation without interrupting flow of water a single instant. Built in sizes 2 inches to 48 inches. Ask for catalog R-1.

Lagonda Automatic Cut-Off Valve closes automatically and prevents injury to employees, and forestalls costly shut-downs of plant, should a break occur anywhere in a boiler tube or in the steam line.



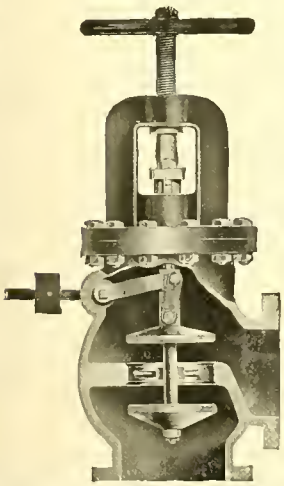
Weinland Turbine Cleaner

The Weinland Turbine Cleaner back of a Weinland Quick Repair Head is best suited to ordinary boiler conditions and removes scale from tubes in the shortest possible time and with a minimum amount of water. We also make similar cleaners that can be driven by steam or compressed air.

Lagonda Reseating Machine cleans the faces, caps and nuts of B. & W. and similar boilers 16 *times as fast* as can be done by hand. The emery wheel is driven by either an electric, steam or air motor.

Any of the above appliances can be had on trial.

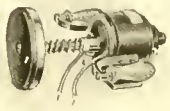
For further information write for special bulletins



Lagonda Automatic Cut-Off Valve

The Lagonda Mfg. Co.
SPRINGFIELD, OHIO.
FUEL SAVING SPECIALISTS
NEW YORK, BOSTON, PHILADELPHIA, ST LOUIS, CHICAGO, DETROIT, DENVER
DALLAS, SAN FRANCISCO, ST. PAUL, MONTREAL, LONDON.

Makers of Weinland Tube Cleaners, Automatic Cut-Off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers 108



Lagonda Reseating Machine

When Selecting Belt Pulleys What Tests Do You Apply?

Note these tests that have proved

"American" Steel Split Pulleys

Patented

The Test of Time

The "American" is the original steel pulley, with sixteen years of continuous and ever increasing success behind it, and more to come.

The Test of Service

"American" Pulleys are fully guaranteed. The company is not called upon to replace two pulleys in every thousand that it sells.

The Test of Adaptability

"Americans" are parting pulleys. They may be bushed to fit various sizes of shaft, and are competent to perform either single or double belt service.

The Test of Popularity

"Americans" are probably the most widely used metal pulley in this country. Over two millions have been distributed.

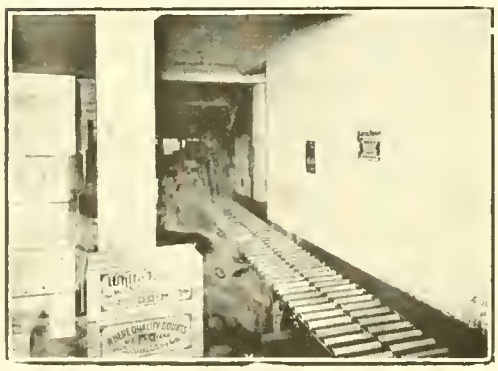
These facts are not accidental, but result from superiority of construction. A postal will bring you "Factors of Energy"—a booklet fully describing "American" pulleys, and containing general information useful to mill men. It's worth a cent to you.

Perfect in Principle Powerful in Performance

THE AMERICAN PULLEY COMPANY

OFFICE AND WORKS: PHILADELPHIA, PA

New York, N. Y. Cor. Grand & Greene Sts. | Boston, Mass. 165 Pearl St. | Chicago, Ill. 124 S. Clinton St.



The Engineer who specifies

MATHEWS GRAVITY CONVEYER SYSTEMS, AUTOMATIC ELEVATORS, GRAVITY SPIRALS and SPIRAL CHUTES

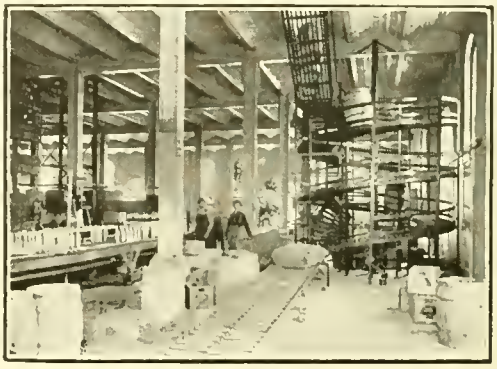
Relieves himself of all worry and responsibility. Our handling equipment is absolutely trouble-proof and dependable. We stand back of every installation with a guarantee of perfect performance and maximum service.

THE MATHEWS CO. PUT THE FIRST STEEL, BALL-BEARING GRAVITY CONVEYERS ON THE MARKET—NOW RECOGNIZED AS STANDARD

ATTENTION OF MECHANICAL ENGINEERS

Cut out this coupon, attach it to your letter head and we will mail our full set of catalogs and bulletins illustrating and describing the Mathews line of Standard equipment, consisting of Gravity Conveyers, Automatic Elevators, Gravity Roller Spirals, Gravity Spiral Chutes, etc. Sooner or later you will have use for the information given in our literature.

In every leading American city we have competent engineers who stand ready to cooperate in designing suitable Conveyer Systems for handling almost every known commodity, exclusive of bulk materials, such as coal, ashes, etc. Our standard equipment represents efficiency of the highest class in design, materials and workmanship. We cater only to consumers who want quality in preference to low price.



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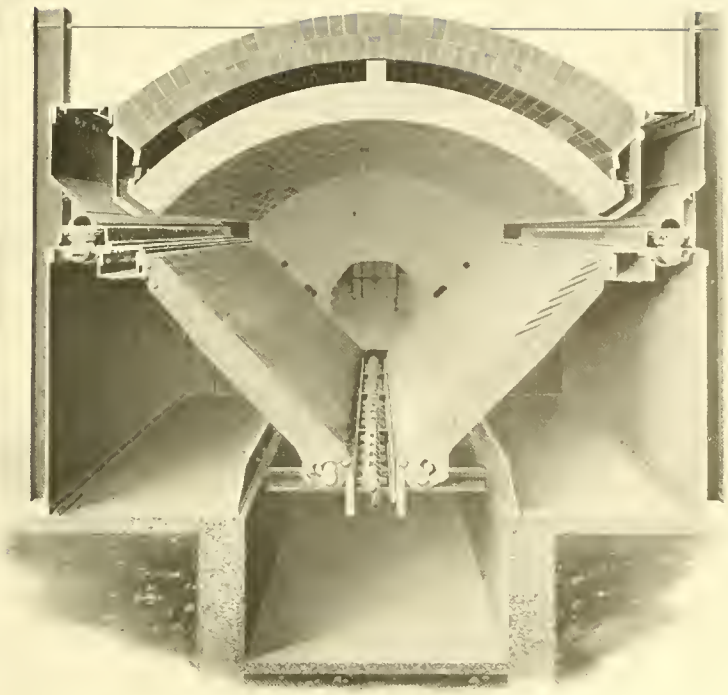

TRANSVERSE SECTION—REAR VIEW

Murphy Automatic Smokeless Furnaces

Adaptable to all types and sizes of boilers. Feed and distribute all grades of bituminous fuels and remove the ash and refuse. Have been raising efficiency of boilers and reducing fuel expense for

36 YEARS

in many plants; and the testimony of those who have benefited by Murphy Furnace installations is convincing. Let us send you a list of some contributors to our "Repeat Orders" file.

Write today for literature that leads direct to big savings

Murphy Iron Works

Detroit **Buffalo**

101

WESTON

Miniature Precision Instruments for Direct Current

A new group of very small Indicating Instruments
COMPACT — ACCURATE — DURABLE — BEAUTIFUL

MODEL 280, Single Range Portable Voltmeter. (One-quarter Size.)

MODEL 280, Triple Range Portable Volt-Ammeter. (One-quarter Size.)

PORTABLE

Voltmeters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters, are supplied in single, double and triple ranges.

The triple range volt-ammeter comprising six instruments in one. This group also includes BATTERY TESTERS.

SWITCHBOARD

Voltmeters Volt-Ammeters Ammeters Mil-Ammeters

This new line of instruments represents the latest development of the pivoted moving coil, permanent magnet type for low ranges.

The refinement of design and mechanical work in them has been carried to a degree which would appear to be almost impossible of accomplishment, if the results were not evident in the instruments themselves.

They embody characteristics which have made the well known Weston Standards famous throughout the world.

They are accurate, dead beat and extremely sensitive.

They may be left continuously in circuit at full load without injury and are shielded against the external electrical and magnetic influences of other apparatus in their vicinity.

They are substantially constructed and may be safely sent long distances through the mails and will withstand an extraordinary amount of vibration without injury.

MODEL 267, Switchboard Ammeter. (One-quarter Size)

MODEL 268, Switchboard Volt-Ammeter. Reads Amperes. Press Button for Volts. (One-quarter Size.)

They have the longest scale ever provided in instruments with equal length of pointer.

Each model has been thoroughly tested under the most severe conditions of service and in experiments extending over more than one year.

The portable instruments may be conveniently carried in the coat pocket.

The prices have been established upon so low a scale that any one may possess one or more of these remarkable instruments at moderate cost.

If you cannot obtain the instruments desired from your dealer, write us.

The several models and ranges offer a selection from over 300 different combinations, listed in Bulletin No. 8. Will be mailed upon request.

WESTON ELECTRICAL INSTRUMENT COMPANY,

Main Office and Works, NEWARK, N. J.

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Chicago, 832 Monadnock Block.
Boston, 176 Federal St.
Philadelphia, 342 Mint Arcade.
Birmingham, Amer. Trust Bldg.

St. Louis, 915 Olive St.
Denver, 231 15th St.
San Francisco, 682 Mission St.
Cleveland, 1729 E. 12th St.
Detroit, 618 Union Trust Bldg.

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I. P. MORRIS COMPANY

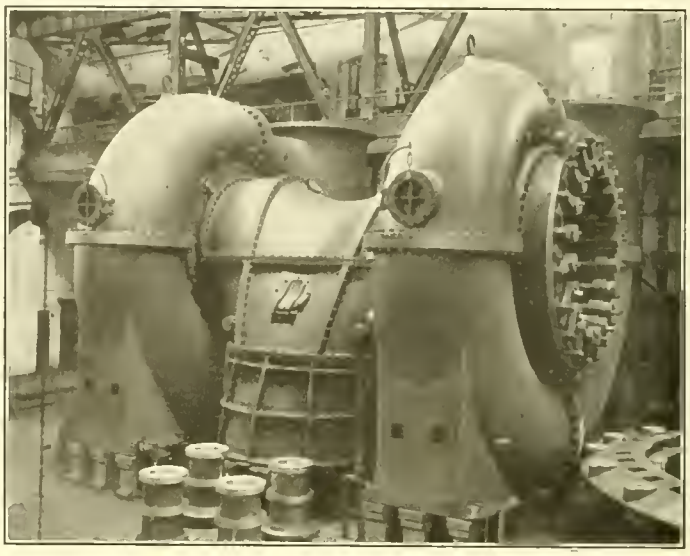
PHILADELPHIA, PA.

Specialists in the Design and Construction of High Class, High Power, and High Efficiency Hydraulic Turbines

The I. P. Morris Company in 1851 built its first hydraulic turbines, which were used continuously by the Water Works Department of Philadelphia until superseded by the present filtration system in 1908.

Total capacity of turbines built or under construction by I. P. Morris Company since it began active construction of hydraulic turbines now aggregate 1,645,000 horse-power.

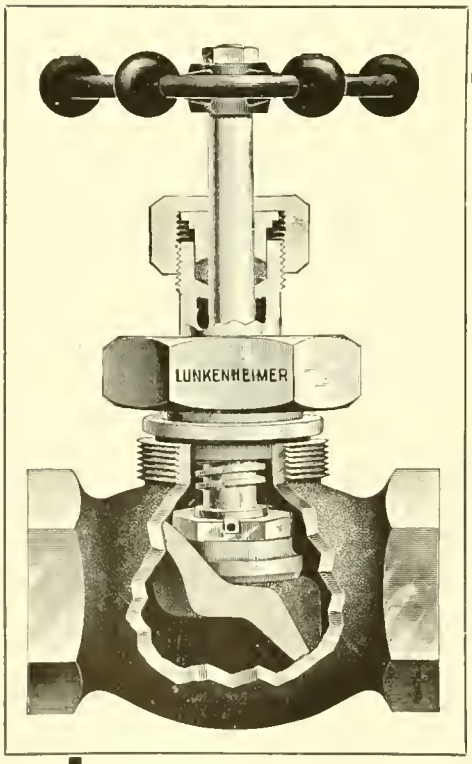
Inquiries for turbines requiring special design will be given every attention.



22,500 H. P. TURBINE

Two units furnished. Head 168 Feet. Speed 200 R. P. M.

Most Powerful Water Turbines in existence



LUNKENHEIMER REGRINDING VALVES

The Valves That Last and Satisfy

Seating surfaces regrindable.

All parts renewable.

Material used—a high grade bronze composition formulated in our own laboratories.

Made only by skilled workmen.

Passages through bodies free and unobstructed.

Stuffing-boxes can be repacked under pressure.

Thoroughly tested and carefully inspected before leaving the factory.

Made in two weights—Medium for steam working pressures up to 200 pounds and Extra Heavy up to 300 pounds per square inch—sizes ½ to 4 inches.

Guaranteed to be exactly as represented.

Specify and insist upon securing genuine **Lunkenheimer make.** Do not accept substitutes—they are never as good as the genuine.

Your local dealer can furnish them; if not, write us.

THE LUNKENHEIMER CO.

"QUALITY"

Largest Manufacturers of High Grade Engineering Specialties in the World

Executive Offices and Factories: CINCINNATI, OHIO, U. S. A.

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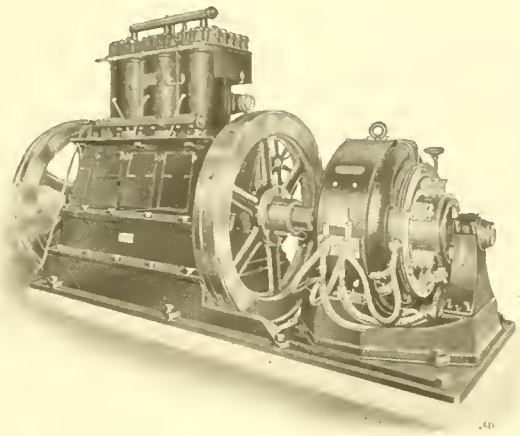
3-4

THE NASH ENGINE

ILLUMINATING NATURAL OR PRODUCER GAS.
IS THE MOST RELIABLE AND ECONOMICAL.



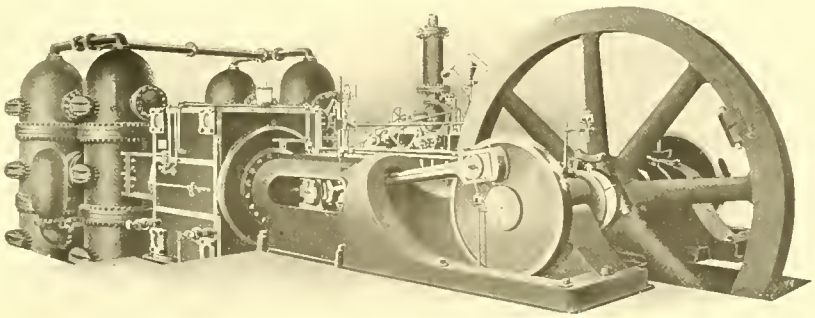
NATIONAL METER COMPANY

CHICAGO NEW YORK BOSTON

HAMILTON CORLISS

Horizontal Crank and Fly Wheel Pumping Engines

are particularly designed for hard service and long life and the valves are arranged in the annealed steel casting decks in such manner that the flow of water is not deflected in all directions, as is necessarily the case when the bee-hive or cage system is used.



Hamilton Corliss Engines are the most economical steam operated prime movers known and are sold on their operating record.

Send for Bulletin "F"

THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO, U. S. A.

Consult the Cowdrey Machine Works

If you want your new idea put into form.

If you want your plans held and work executed in strict confidence.

If you want your special machine built right in every detail.

If you want your machine work furnished on a contract basis.

If you want to be relieved of every detail of the manufacturing end.

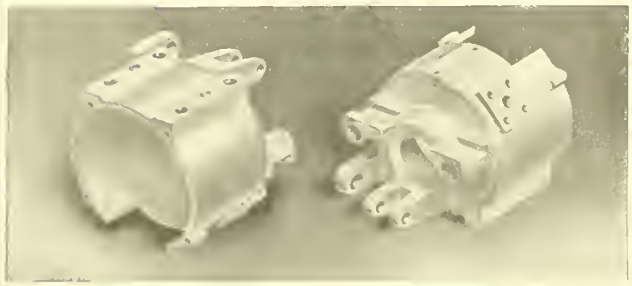
Forty years' experience in building special machines for knitting mills, paper making, wood working and nearly every other kind of purpose, has fitted us to help you solve your own problems.

Estimates gladly furnished from blue-prints. Write us to-day

C. H. COWDREY MACHINE WORKS

FITCHBURG, MASS.

Contractors, Builders and Designers of Special Machinery



Doehler Die-Cast Speedometer Housing

DIE CASTINGS

In Aluminum and White Metal Alloys
Babbitt-Lined Bronze Bearings

Metals used by us are under the supervision of competent chemists and we have every facility for precision, uniformity and quantity production.

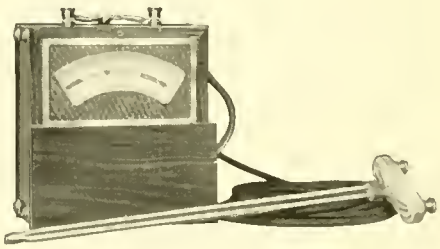
We invite correspondence and gladly furnish samples upon request. Upon receipt of specifications and information as to the quantities required, quotations will be submitted promptly.

DOEHLER DIE-CASTING CO.

COURT & NINTH STS.
BROOKLYN, N.Y.

2

Brown Pyrometers



Meet every requirement in the measurement of temperatures up to 3600° or as low as —200°. Brown High Resistance Pyrometers are unaffected by the length of wire connecting the thermo-couple and indicator. Our 56-page Catalogue describes other advantageous features.

THE BROWN INSTRUMENT CO.

PHILADELPHIA, PA.

NEW YORK PITTSBURGH CHICAGO

Inertia

The resistance to motion, we are told, is the bane of industrial progress—the inability of men to grasp fully their opportunities. But where absolute confidence reposes in the adviser we are loath to believe this can be very generally true.

Goodrich LONGLIFE and MAXECON CONVEYOR BELTS

reduce tonnage cost.

The confidence in our ability to effect maximum economy and efficiency in this field of industry, rests mainly upon present and past accomplishments. These are, we feel, but the logical result of ripe experience matched with persistent striving toward consistent production.

Elevator Belts	Packing
Transmission Belts	Valves
Air Drill Hose	Matting, etc.

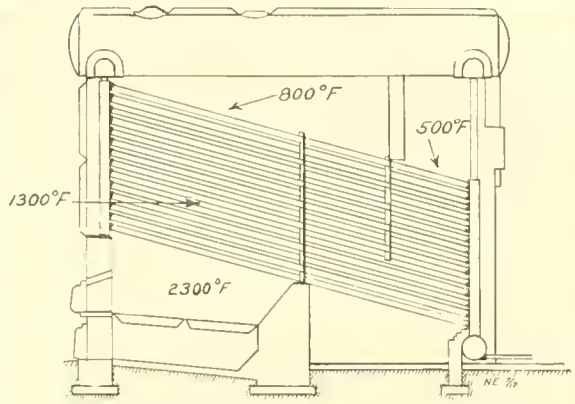
The B. F. Goodrich Co.

Factories: Akron, Ohio

Branches in All Principal Cities

There is nothing in Goodrich Advertising that isn't in Goodrich Goods

Makers of Goodrich Tires and Everything that's Best in Rubber

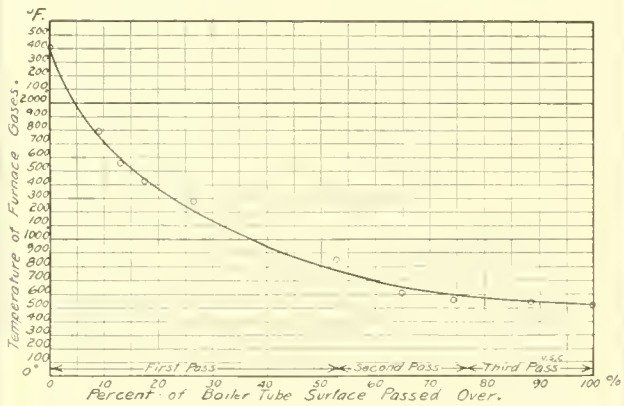


The Last Pass of a Boiler Does Not Pull Its Own Weight

That is, does not absorb enough heat to pay fixed charges.

The temperatures shown in the above drawing are taken from a test on a water tube boiler containing 6000 square feet of surface arranged in 14 rows of 18-foot tubes, each 4 inches in diameter. The temperatures were obtained by means of an electrical pyrometer when operating the boiler at about nominal load, and show that the first five rows in the first pass absorbed 55 per cent of all the heat recovered, and that the second and third passes abstracted less than 16 per cent of the heat absorbed by the boiler.

Tests made on another boiler gave the relations indicated in the following chart:



Obviously it does not pay to reduce the temperature of the flue gases below 600 or 700 deg. F. by means of boiler surface alone. But on the other hand, to throw the gases away at this temperature involves a loss of 25 to 40 per cent of the total heating value of the fuel.

The remedy is to substitute for the additional boiler surface, economizer surface, which, because of the lower temperature of its contents, absorbs heat more rapidly than does the surface in the last pass of the boiler. Moreover, the fixed charges upon the economizer surface are less, square foot for square foot, and it is therefore able to show much higher returns upon the investment than would additional boiler surface.

The various engineering phases of this subject are fully discussed in our new 100-page ECONOMIZER CATALOG "M. E. 142," which contains numerous figures, charts, etc. Sent upon request to anyone who owns, designs, manages or operates steam boilers.

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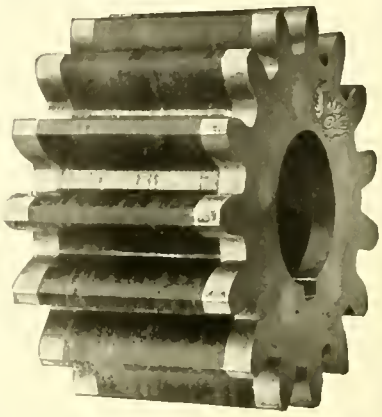

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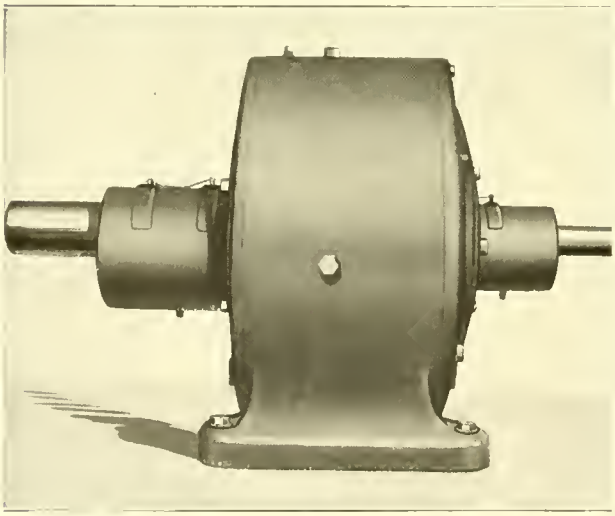

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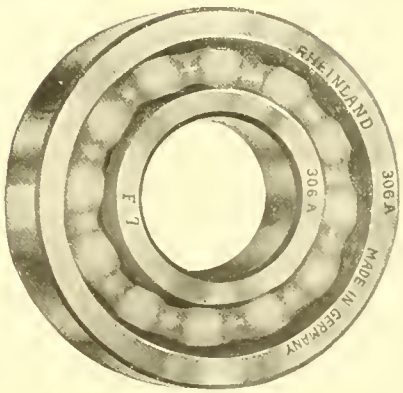

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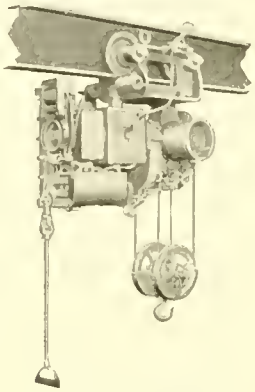

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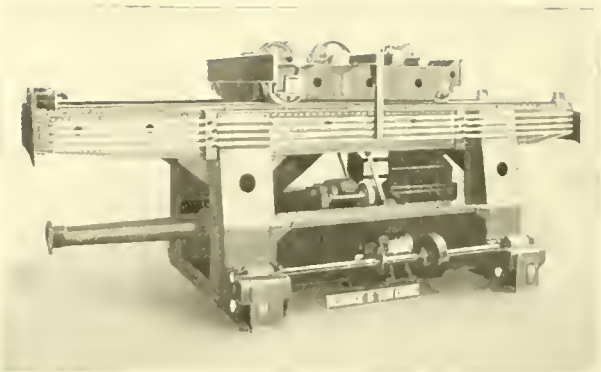

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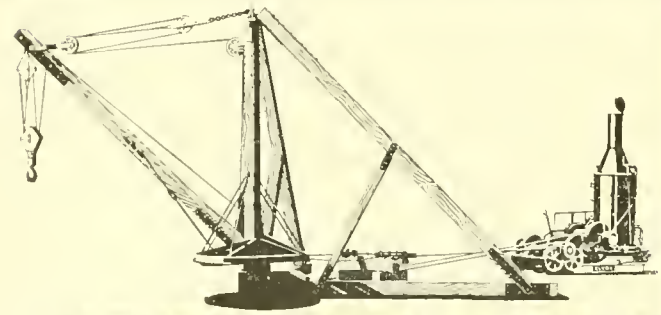

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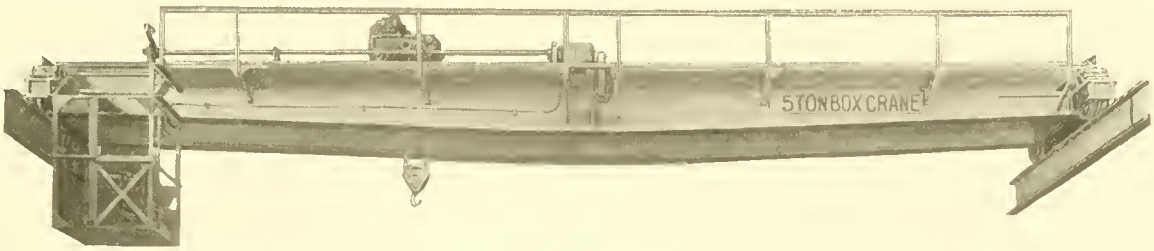

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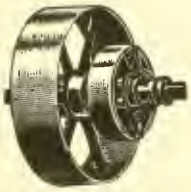

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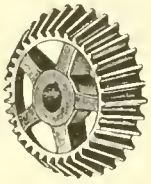

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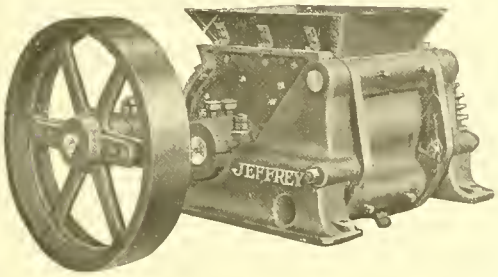

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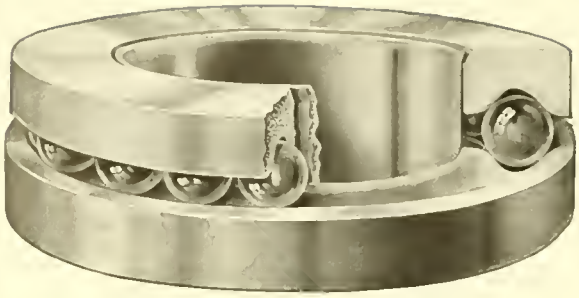

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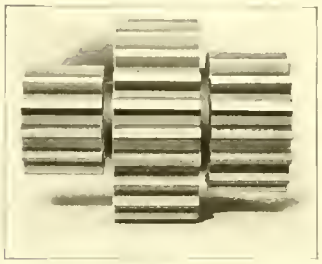

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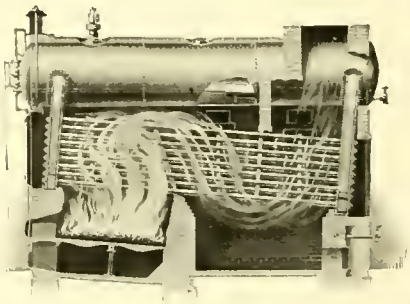

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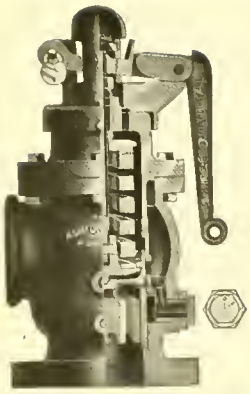

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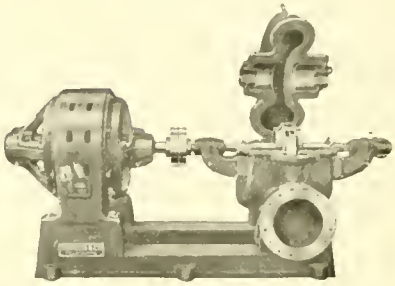

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Builders of Corliss Engines, Girder or Heavy Duty Type Bed for Belted or Direct-Connected Service, medium or high speed. Ice and Refrigeration Machines.

Blast Furnace Blowing Engines

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Builders of Blast Furnace Blowing engines and equipments. Cinder and hot metal cars. Furnace Bells and Hoppers. Rolling Mill castings. Special attention paid to quick repair work and work governed by Engineers' specifications.

Papers on Steam Engines and Boilers

PAPERS PUBLISHED BY A. S. M. E.

No. 1071. Influence of the Connecting Rod Upon Engine Forces: S. A. Moss, price $0.10; No. 922. Effect of Clearance on Economy of Steam Engine: A. Kingsbury, price $0.10; No. 873. Comparison of Rules for Calculating the Strength of Steam Boilers: H. de B. Parsons, price $0.10; No. 819. Boiler and Furnace Efficiency: R. S. Hale, price $0.30.

OIL AND GAS ENGINES AND GAS PRODUCERS

Refrigerating and Ice Making Machinery

Oil and Gas Engines

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Refrigerating and Ice Making Machinery, 5 to 600 tons capacity; Oil Engines up to 360 B. H. P.; Gas Engines 75 to 2400 B. H. P.

See page 20 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Oil Engines

AUGUST MIETZ IRON FOUNDRY & MACHINE WORKS 123 Mott St. NEW YORK

Oil Engines, Marine and Stationary, 2–400 h.p., 200,000 h.p. in operation. Direct coupled or belted to Generators, Air Compressors, Pumps, Hoists, etc., etc.

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Nash Gas Engines and Producers are capable of running at their rated load for ten consecutive hours on one charge of fuel; will develop a B. H. P. hour on one pound of coal; are reliable because they're Nash.

See pages 18, 19 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Gas Producers

THE SMITH GAS POWER CO. LEXINGTON, OHIO

Builders of Smith Automatic Gas Producers, both suction and pressure types. Mechanically Operated Gas Producers in large units for power and heating plants. Tar Extractors and Gas Cleaning Plants.

See page 22 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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AMERICAN BALANCE VALVE CO.

JERSEY SHORE, PENNA.

Valves

Slide and Piston Distribution

We make Balanced Slide and Piston Valves for Manufacturers of Steam Engines, also for Old Power Equipment, from Steam Pumps to Battleships. Write us.

See page 130 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

AMERICAN STEAM GAUGE AND VALVE MFG. CO.

BOSTON, MASS.
ESTABLISHED 1851

Valves

Gages

Indicators

Pressure and Recording Gauges, Engine Room Clocks and Counters for all purposes. Iron and Brass Pop Safety and Relief Valves for stationary, marine and locomotive use. The American Thompson Improved Indicator with new improved detent motion. The American Ideal Steam Trap.

See pages 110, 111 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

THE ASHTON VALVE CO.

BOSTON NEW YORK CHICAGO

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Gages

Makers of the Ashton Pop Safety Valves, Water Relief Valves, Blow Off Valves, Pressure and Vacuum Gages. All of a superior quality and guaranteed to give greatest efficiency, durability and perfect satisfaction.

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Furnaces

Apparatus for and technical information relative to all forms of liquid fuel equipment.

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Recording Gauges and Instruments

Bristol's Recording Pressure and Vacuum Gauges. Bristol's Recording Thermometers. The Wm. H. Bristol Electric Pyrometers. Bristol's Recording Voltmeters, Ammeters and Wattmeters. Bristol's Recording Water Level Gauges. Bristol's Time Recorders and Bristol's Patent Steel Belt Lacing.

THE BROWN INSTRUMENT CO.

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Tachometers

Manufacturers of the Brown Pyrometers, the first to be manufactured in this country, and having the largest sale today. Also manufacturers of Thermometers, Speed Indicators and Recorders, Voltmeters, Ammeters and kindred instruments.

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Brass and Iron Valves for steam, water, gas, oil, etc. Sluice Gates. Send for catalogue.

See page 76 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

CRESCENT MANUFACTURING CO.

SCOTTDALE, PA.

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Grease Cups

Lackawanna Sight Feed Lubricators and Automatic Grease Cups.

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CHICAGO
NEW YORK ST. LOUIS

Valve Specialties

Steam Traps

Governors

Manufacturers of Pressure Reducing Valves, Back Pressure Valve, Steam Trap, Exhaust Relief Valves, Balanced Valve, Float Valve, Pump Governor, Boiler Stop and Check Valves.

See pages 104, 105 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Condensing Plants
Air Filters
Separators
Steam Traps

GENERAL CONDENSER CO.

1250 12th St. PHILADELPHIA, PA.

Complete Condensing Plants for High Vacuum; Counter Current, Jet and Surface Condensers, Air Pumps, Pumping Outfits, Re-Cooling Plants. Oil, Air and Steam Separators. Combined Oil Separators and Heaters. Dry and Wet Air Filters. Air Extractors for Feed Water ("Airex"). Return and Vacuum Steam Traps.

Stokers
Pneumatic Ash Conveyors

GREEN ENGINEERING CO.

Steger Building CHICAGO, ILL.

Green Chain Grate Stokers for free burning and coking bituminous coals. GECO Pneumatic Ash Handling Systems.

See pages 32, 33, 34 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Feed-Water Heaters and Purifiers
Separators
Metering Heaters

HARRISON SAFETY BOILER WORKS

PHILADELPHIA, PA.

Cochrane Feed Water Heaters, Cochrane Steam and Oil Separators, Sorge-Cochrane Hot Process Softening Systems, Cochrane Multiport Valves, Cochrane Metering Heaters.

Valves

HOMESTEAD VALVE MANUFACTURING CO.

Works: HOMESTEAD, PA. PITTSBURG, PA.

Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most difficult service for water, air or steam. Valves unlike all others.

See page 82 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves
Steam Traps
Separators
Regulators

THE HUGHSON STEAM SPECIALTY CO.

CHICAGO, ILL.

Manufacturers of Regulating Valves for all pressures and for steam, air and water. The best and only absolutely noiseless Combination Back Pressure and Relief Valve. Pump Regulators, Separators, Steam Traps, Automatic Stop and Check Valves. Write for complete catalogue.

Air Compressors
Air Tools and Hoists

INGERSOLL-RAND COMPANY

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Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

See pages 276, 277 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves
Packing Discs

JENKINS BROS.

NEW YORK BOSTON PHILADELPHIA CHICAGO

Manufacturers of the genuine Jenkins Bros. Valves, made in brass, iron body, and cast steel, in a variety of types suitable for moderate, medium or extra heavy pressures. Also a line of high grade mechanical rubber goods including sheet packing, gasket tubing and pump valves. Illustrated catalogue sent on request.

See pages 84, 85 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Magnesia Asbestos and Brine Pipe Coverings

ROBERT A. KEASBEY CO.

100 N. Moore St. NEW YORK CITY
Telephone: 6097 Franklin

Heat and Cold Insulating Materials. Headquarters for 85% Magnesia Asbestos and Brine Pipe Coverings, Asbestos Products, etc.

See page 138 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves
Blow-off Valves
Fire Hydrants

THE LUDLOW VALVE MFG. CO.

TROY, N. Y.

Manufacturers of genuine Ludlow Gate Valves for all purposes. Special Blow-off Valves. Check Valves. Foot Valves. Sluice Gates. Indicator Posts. Fire Hydrants.

See pages 86, 87 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves
Fire Hydrants

THE PRATT & CADY COMPANY

HARTFORD, CONN.

Branches at Albany, Baltimore, Boston, Chicago, Detroit, Indianapolis, New Orleans, New York, Philadelphia, Pittsburg.

Manufacturers of Brass, Iron and Steel Valves, Fire Hydrants, Asbestos Packed Cocks.

See pages 96, 97 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

Valves
Injectors
Lubricators
Etc.

Manufacturers of high-grade engineering specialties, comprising Brass and Iron Valves, Whistles, Cocks, Gauges, Injectors, Lubricators, Oil Pumps, Oil and Grease Cups, etc., adapted to the requirements of all classes of machinery.

See pages 88–93 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

MOREHEAD MANUFACTURING CO.

DETROIT, MICH

Steam Traps

Return, Non-Return, Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

See pages 112, 113 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

THE MURPHY IRON WORKS

Founded 1878 Inc. 1904 DETROIT, MICH

Automatic Furnace

Builders of The Murphy Automatic Furnace. The best Automatic Furnace that thirty years practical experience can produce.

See pages 38, 39 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

NELSON VALVE CO.

CHESTNUT HILL PHILADELPHIA, PA

Valves

Manufacturers of high grade Bronze, Iron and Steel Valves of every kind for every purpose.

See page 94 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

THE PICKERING GOVERNOR CO.

PORTLAND, CONN

Governors

Governors for Steam Engines, Turbines, Gas Engines. Mechanical Control Power Regulation.

See page 131 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

POWER SPECIALTY CO.

111 BROADWAY NEW YORK

Superheaters

The Foster Patent Superheater saves feed water, condensing water, coal and boiler power.

See page 45 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

WM. B. SCAIFE & SONS COMPANY

221 FIRST AVE. PITTSBURGH, PA.
26 CORTLANDT ST. NEW YORK

Water Softening
Purifying and Filtering Systems

WE-FU-GO and SCAIFE Water Softening, Purifying and Filtering Systems for boiler feed water and all industrial and domestic purposes.

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Injectors
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Engine Stops

Injectors, Syphons, Eductors, Furnace Blowers, Exhausters, Pump Primers, Condensers, Spray Cooling Nozzles; Valves; Small Brass and Iron Body, Open Hearth Steel-Stop, Stop Check, Emergency Stop Check, Trip, Throttle Trip, Engine Stops, Steam Traps, Feed Water Heaters, etc.

C. J. TAGLIABUE MFG. CO.

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Local Sales Offices in Chicago and San Francisco

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Manufacturers of Instruments for Indicating, Recording and Controlling Temperature and Pressure. Thermometers; Automatic Controllers; Gages; Oil Testing Instruments; Engineers' Testing Sets, Pyrometers, Barometers, Hygrometers, Hydrometers, etc.

See Page 132 of Condensed Catalogues of Mechanical Equipment.

THE TEXAS COMPANY

NEW YORK HOUSTON

Lubricating Oils

Lubricating Oils for Power Plants, Central Stations, Machine Shops, Foundries and all general purposes. All classes of Petroleum Products of the highest quality.

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Condensers
Pumps
Cooling Towers

WHEELER CONDENSER & ENGINEERING CO. MAIN OFFICE AND WORKS: CARTERET, N. J.

Surface, Jet and Barometric Condensers, Combined Surface Condensers and Feed Water Heaters, Cooling Towers, Edwards Air Pumps, Centrifugal Pumps, Rotative Dry Vacuum Pumps and Multiple Effect and Evaporating Machinery.

See page 66, 67 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Condensers
Cooling Towers
Feed-Water Heaters

C. H. WHEELER MFG. CO. PHILADELPHIA, PA. NEW YORK BOSTON CHICAGO SAN FRANCISCO

Manufacturers of High Vacuum Apparatus, Condensers, Air Pumps, Feed-Water Heaters, Water Cooling Towers, Boiler Feed and Pressure Pumps.

See page 65 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Water Meters
Blow-off Valves
Pipe-Joint Clamps

YARNALL-WARING CO. CHESTNUT HILL PHILADELPHIA, PA

Manufacturers of the "Lea" V-Notch Recording Meter, Simplex Seatless Blow-off Valve and the Simplex Pipe-Joint Clamp.

See page 95 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Papers on Power Plant Specialties

PAPERS PUBLISHED BY A. S. M. E.

No. 1085. Performance of a Superheater: A. Bement, price $0.10; No. 1070. A Twist Drill Dynamometer: H. P. Fairfield, price $0.10; No. 921. The Bursting of Small Cast Iron Fly-Wheels: C. H. Benjamin, price $0.20; No. 1111. Balancing of Pumping Engines: A. F. Nagle, price $0.10.

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THE AMERICAN PULLEY CO. PHILADELPHIA, PA.

The American Pulley. The first all steel parting belt pulley made. Now sold in larger quantities than any one make of pulley. No key, no set screw, no slip; light, true and amply strong for double belts. 120 stocks carried in the United States.

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AUBURN BALL BEARING COMPANY 22 ELIZABETH ST. ROCHESTER, N. Y.

Auburn Four Point Contact Cone Principle Ball Thrust Bearings, Auburn Special Ball Thrust Bearings, Auburn Steel, Brass and Bronze Balls, Solid and Hollow.

See page 161 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Shafting
Pulleys
Hangers

THE A. & F. BROWN CO. 79 BARCLAY ST. NEW YORK

Manufacturers of Shafting, Pulleys, Hangers, etc., for Transmission of Power.

See page 148 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Power Transmission
Elevators
Conveyors

DODGE MANUFACTURING CO. MISHAWAKA, IND.

Manufacturers of everything for the Mechanical Transmission of Power; also Elevating and Conveying machinery, and the "Eureka" Water Softener. Our new catalog 106A14 gives an idea of the Dodge line.

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High grade Ball Bearings made of the finest materials to the closest standards of accuracy in the world. Fafnir Ball Bearing Hanger Boxes can be used in any standard hanger frame.

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Power Transmission Appliances

Friction Clutch Pulleys, Couplings, Quills, Operators, Clutch Sheaves, Floor Stands, Heavy Mill Bearings, Shaft Couplings, Sheaves and Tension Carriages, Pulleys and Fly Wheels.

See page 149 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

THE HILL CLUTCH COMPANY

CLEVELAND, OHIO

Power Transmission

Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

See page 156 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

D. O. JAMES MANUFACTURING CO.

1120-22 W. MONROE ST. CHICAGO

Cut Gearing

Speed Reducing Transmissions

Specialists in cut gearing; spur, spiral, bevel, mitre, worms and worm gears, rawhide pinions, racks, incased worm gear reductions, O'K speed reducing transmissions 4:1 up to 1600:1.

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FACTORIES: DÜSSELDORF, GERMANY; PARIS, FRANCE; NEW BRITAIN, CONN.

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Rhineland Ball Bearings are made for all machinery purposes, and include every desirable type and size.

See page 164 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

THE ROCKWOOD MANUFACTURING CO.

INDIANAPOLIS, IND.

Pulleys

Paper Friction Transmission

Rockwood Paper Frictions have proven their unquestioned superiority. You will find our booklets regarding Transmission of Power by Belts and Friction Transmission desirable additions to your engineering library.

L. B. WILLIAMS AND SONS

DOVER N. H.
NEW YORK BOSTON CHICAGO

Leather Belting

Lace Leather and Wetting

Tanners and Manufacturers of Oak Tanned Leather Belting, Round Belting, Lace Leather, Belt Leather, Welting, Strapping, Finished Oak Shoulders, Slabs, Bellies, Scrap Leather.

T. B. WOOD'S SONS CO.

CHAMBERSBURG, PA.

Power Transmission

Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

See pages 154, 155 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

PAPERS PUBLISHED BY A. S. M. E.

Papers on Power Transmission

No. 1276. Symposium on Electric Driving in Machine Shop: A. L. DeLeeuw, C. Robbins, J. Riddell and discussion, price $1.10; No. 1335. Variable-speed Power Transmission: G. H. Barrus and C. M. Menly, price $0.10; No. S 47 X. A New Theory of Belt Driving: S. Haar, price $0.20; No. 1230. Transmission of Power by Leather Belting: C. G. Barth, price $0.50.

HOISTING AND CONVEYING MACHINERY

ALLIANCE MACHINE CO.

ALLIANCE, OHIO

Cranes

Steam Hammers

Punches and Shears

Makers of Alliance Cranes of all types; also Rolling Mill and Hydraulic Machinery, Steam Hammers, Punches and Shears, Scale Cars, Copper-Converting Machinery, etc.

See page 199 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Cranes and Hoists

ALFRED BOX AND COMPANY

PHILADELPHIA, PA.

Electric and Hand Power Cranes, Portable Electric and Monorail Hoists, Complete Track Systems.

Hoisting Machinery

THE BROWN HOISTING MACHINERY CO.

CLEVELAND, O., U. S. A.
NEW YORK SAN FRANCISCO
PITTSBURGH CHICAGO

Designers and Manufacturers of all kinds of Hoisting Machinery, including Locomotive Cranes, Electric Travelers, I-beam Trolleys, Crabs, Winches, etc., as well as heavy Hoisting Machinery of all descriptions. Also Ferroinclave for reinforced concrete roofing.

See page 201 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Conveyors
Elevators
Power Transmission

H. W. CALDWELL & SON COMPANY

NEW YORK CHICAGO

Elevating, Conveying and Power Transmitting Machinery. Helicoid and screw conveyors, machine molded gears, pulleys, fly-wheels, rope sheaves and drives, sprocket wheels and chain, buckets, belting, shafting and bearings.

See page 187 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Hoisting Engines and Derricks

CLYDE IRON WORKS

DULUTH, MINN.

Hoisting Engines and Derricks. All sizes and types of engines.

See page 201 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Elevators
Friction Clutches
Pulleys

THE EASTERN MACHINERY COMPANY

NEW HAVEN, CONN.

Manufacturers of Electric and Belt Power Passenger and Freight Elevators, Hoisting Machines, Friction Winding Drums, Friction Clutches and Friction Clutch Pulleys.

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THE B. F. GOODRICH CO.

AKRON, OHIO

Manufacturers of Goodrich Conveyor Belt. The Goodrich "Longlife" "Maxecon" and "Grainbelt" Conveyors will handle more tons per dollar of cost than any other belt made.

See pages 146, 175 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Elevating
Conveying
Mining Machinery

THE JEFFREY MFG. COMPANY

COLUMBUS, OHIO

Builders of Elevating, Conveying and Mining Machinery; Coal and Ashes Handling Systems for Power Plants; Screens, Crushers, Pulverizers, Car Hauls, Coal Tipples, Coal Washeries, Locomotives, Coal Cutters, Drills, etc. Complete Coal Mine Equipments.

Hoisting Engines
Cableways
Marine Transfers

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Hoisting Engines—steam and electric, for every use of the contractor, miner, warehouseman, railroads, shipowners, etc. Derricks, Derrick Irons and Derrick Hoists, Cableways for hoisting and conveying, Marine Transfer for coal and cargo handling.

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LINK-BELT COMPANY

PHILADELPHIA CHICAGO
INDIANAPOLIS

Elevators and Conveyors for every purpose; all accessories; Power Transmission Machinery. The Link-Belt Silent Chain Drive, Coal Tipples, Coal Washeries, Locomotive Cranes, etc.

See page 192 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Gravity Carriers
Conveyers
Automatic Elevators

MATHEWS GRAVITY CARRIER CO.

ELLWOOD CITY, PA.

Manufacturers of Gravity Carriers, Conveyers, Spirals, Chutes, and Automatic Elevators. Engineering Department at your service.

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO

Are the largest builders of Electric Traveling Cranes in the world. We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

Cranes

ROBINS CONVEYING BELT COMPANY

13 PARK ROW NEW YORK

The Robins Belt Conveyor was the original and is today the standard of this type of conveying machinery. It is successfully and economically conveying ore, rock, coal and similar materials under the most trying conditions of service. Correspondence invited.

See page 193 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Robins Belt Conveyors

JOHN A. ROEBLING'S SONS COMPANY

TRENTON, N. J

Manufacturers of Iron, Steel and Copper Wire Rope, and Wire of every description.

See page 185 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Wire Rope

SHAW ELECTRIC CRANE CO.

MUSKEGON, MICH.

Electric Travelers for all purposes. Gantries. Wharf Cranes. Railroad Wrecking Cranes. Mono-Rail Systems. Electric Motor Controllers.

Cranes

Mono-Rail Systems

Controllers

THE TOLEDO BRIDGE & CRANE CO.

TOLEDO, OHIO

Toledo Cranes and Hoists; Coal and Ore Handling Bridges; Grab Bucket Machinery; Electric and Hand Power Cranes, all types, any capacity; Structural Steel for Factory Buildings.

Cranes

Hoists

THE WEBSTER M'F'G COMPANY

(Successors to WEBSTER M'F'G CO.) TIFFIN, OHIO
EASTERN BRANCH, 88-90 READE ST. NEW YORK

Manufacturers of Elevating, Conveying and Power Transmitting Machinery for all purposes. Over thirty years' experience in this line and extensive facilities for manufacturing give us large advantages. Belt Conveyors for handling cements, ores, sand, gravel, etc. Coal and Ash Handling Systems for power plants and buildings. Chain belting. Gearing.

Elevating

Conveying

Power Transmitting Machinery

PAPERS PUBLISHED BY A. S. M. E.

No. 1235. Automatic Feeders for Handling Material in Bulk: C. K. Baldwin, price $0.10; No. 1234. A Unique Belt Conveyor: E. C. Soper, price $0.10; No. 1300. Operating Condition of Passenger Elevators: R. P. Bolton, price $0.20; No. 1161. A Highspeed Elevator, C. R. Pratt, price $0.40; No. S 52 X. Mechanical Handling of Freight: S. B. Fowler, price $0.20.

Papers on Hoisting and Conveying Machinery

STEEL WORKS AND ROLLING MILL EQUIPMENT

MACKINTOSH, HEMPHILL & CO.

PITTSBURGH, PA.

Engines, single and compound, Corliss reversing and blowing. Rolling Mill and Hydraulic Machinery of all kinds. Shears, Punches, Saws, Coping Machines.

Engines

Rolling Mill Machinery

MESTA MACHINE CO.

PITTSBURGH, PA.
WORKS: Mesta Station, P. R. R., W. Homestead, Pa

Blowing Engines; Rolling Mills; Pickling Machines; Shears; Forging Presses; Gas and Steam Engines; Condensers; Air Compressors; Power Transmission Machinery; Steel Castings; Chilled, Sand and Steel Rolls.

Steel Works and Rolling Mill Equipment

FOUNDRY EQUIPMENT

Sand Rammers
Air Tools and Hoists
Compressors

INGERSOLL-RAND COMPANY

11 Broadway NEW YORK

"Crown" Sand Rammers, floor and bench types; "Crown" and "Imperial" Chipping Hammers; "Imperial" Air Motor Hoists, ½ to 5 tons capacity; Air Compressors, twenty types, capacity 8 to 8000 cu. ft. per minute.

See pages 276, 277 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Foundry Molding Machine Equipment

MUMFORD MOLDING MACHINE CO.

30 Church Street NEW YORK
2075 Elston Ave. CHICAGO, ILL.

Squeezing Machines, Hand or Power
Jolt Ramming Machines, Pneumatic or Electric
Split Pattern Vibrator Machines
Pneumatic Vibrators

See page 216 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Papers on Rolling Mill Machinery

PAPERS PUBLISHED BY A. S. M. E.

No. 868. Some Landmarks in the History of the Rolling Mill: C. H. Morgan, price $0.20; No. 1319. Pressure Recording Indicator for Punching Machinery: C. C. Anthony, price $0.10; No. 1322. Power Forging, with special Reference to Steam Hydraulic Forging Presses: B. Gerdau and G. Mesta, price $0.10.

MACHINE SHOP EQUIPMENT

Special Machinery

C. H. COWDREY MACHINE WORKS

FITCHBURG, MASS.

Contractors, Builders and Designers of Special Machinery.

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THE FELLOWS GEAR SHAPER CO.

SPRINGFIELD, VT.

The Gear Shaper cuts the smoothest gears in use, because the cutter is a theoretically correct generating tool and is ground after being hardened. It is also the fastest machine on the market by 25 to 50%. Literature gives reasons in detail.

See page 235 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Portable Electric Tools

FORTUNA MACHINE CO.

127 Duane St. NEW YORK
Boston, 146 Summer St.
St. Louis, 200 N. 3rd St.

Portable Electric Tools for Drilling, Reaming, Tapping, Grinding and Slotting.

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THE GARVIN MACHINE COMPANY

137 Varick St. NEW YORK CITY

Manufacturers of a complete line of Plain and Universal Milling Machines, Screw Machines, Monitor Lathes, Tapping Machines, Duplex Drill Lathes, Speed Lathes, Cutter Grinders, Automatic Chucks, etc.

Special Machinery

THE HARTFORD SPECIAL MACHINERY CO.

HARTFORD, CONN.

Builders of High Grade, Accurate, Special Machinery, Fixtures, Jigs and Tools.

THE HEALD MACHINE COMPANY

WORCESTER, MASS

Grinding Machines

Manufacturers of Grinding Machines. Internal Grinders, Cylinder Grinders, Surface Grinders, Drill Grinders.

INGERSOLL-RAND COMPANY

11 BROADWAY NEW YORK

Air Compressors

Air Tools and Hoists

Air Compressors, twenty standard types, capacity 8 to 8000 cu. ft. per minute; "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

See pages 276, 277 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

JONES & LAMSON MACHINE CO.

SPRINGFIELD, VT.

Turret Lathes

Manufacturers of the Hartness Flat Turret Lathe; made in two sizes for both bar and chuck work.

See pages 220–225 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

THE KING MACHINE TOOL CO.

CINCINNATI, O.

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MARCH · 1914

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In these and many other ways the Society is serving the profession and each individual member.

Total Membership of the Society, February 15, 1914 ..... *5391*

Net Increase in Membership since January 1, 1914 ..... *9*

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

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COMING MEETINGS

March 4, *Boston, Mass.*, Boston City Club. Annual Joint Dinner, under the auspices of the American Institute of Electrical Engineers. Addresses: The National Government and Business, by Guy E. Tripp of the Westinghouse Electric & Manufacturing Company; Results for the Electrical Engineering Fraternity accomplished by the I. E. C., by A. E. Kennelly, professor of electrical engineering, Harvard University; Ozone applied to Ventilation, by M. W. Franklin of the Sprague Electric Works, Bloomfield, N. J.

March 10, *New York City*, Engineering Societies Building. Subject, Color Photography: its Processes and Results. Papers by F. E. Ives, originator of the tripak and trichrome system of color photography; Westley Allison, representing the Lumiere Jougla process; John Powrie, originator of the Warner-Powrie process. Discussion by Henry Hess of Philadelphia and C. W. Robinson of New York, followed by an open debate.

March 11, *Boston, Mass.*, Wentworth Institute. Papers on Welding by W. N. Best and representatives of the Thompson Electric Welding, Cave Welding, and Goldschmidt-Thermit Companies. A buffet supper will precede the meeting.

March 12, *Buffalo, N. Y.*, University Club. Address: Safety Appliances in Industrial Plants, by John Price Jackson.

March 14, *Philadelphia, Pa.* Paper: The Development of the Steam Plant of the Modern Electricity Supply Station, by I. E. Moultrop.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

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THE SPRING MEETING

The Society is fortunate in its choice of location for the Spring Meeting, which is to be held in St. Paul-Minneapolis on June 16 to 19. St. Paul, with its picturesque location and historic interest, is a most attractive convention city. It is built on a series of hills, the main business portion being situated on a great plateau just above the edge of the Mississippi, while on a hill rising gradually from the river bank stands the beautiful Minnesota State Capitol. The parks scattered over the entire city are a source of unending delight; one of these, Indian Mounds Park, the burying ground of an unknown prehistoric race, lies on the high bluffs overlooking the Mississippi just where the river takes a sweeping bend to the south.

Minneapolis, although an Indian reservation only a little over half a century ago, has now a population of 335,000 inhabitants, and has become the great manufacturing center of the Northwest, as well as one of the most beautiful cities in the country. It owes its beginning to the Falls of St. Anthony, which furnished power for the sawmills to reduce the surrounding forests to lumber. This cleared country was sown to wheat and the Falls turned the millstones which ground it to flour. In this district today are to be found the world's greatest flour mills with a daily capacity of 84,000 barrels, and two of the largest grain elevators in the world.

As last year, there will be three main professional sessions, one on Grain Handling and Ore Handling, a topic to be discussed by local engineers, but of very general interest; the second on Powdered Fuel, which will be treated under four heads: powdered fuel in open-hearth furnaces, in cement kilns, for the generation of steam, and for industrial furnaces; the third session will be devoted to miscellaneous papers, and these are earnestly solicited, especially when giving the results of the individual work of members. Supplementing these three main sessions, it is probable that there will be others arranged by sub-committees.

Among important reports to come up at the Spring Meeting for discussion will be the preliminary report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for Care of Same in Service, and that of the Committee on Flanges, the latter of which was presented for preliminary discussion at the last Annual Meeting.

TENTATIVE PROGRAM

As at present arranged, the program is as follows: On the two opening days the meetings will be held in St. Paul, beginning with a reception on the evening of June 16. Mr. James Hartness, President of the Society, will make introductory remarks, which will be followed by a message to the engineering fraternity by Mr. James J. Hill, former president of the Great Northern System. Dancing will conclude the evening.

Wednesday morning, June 17, will open with a business meeting, to be followed by a professional session. The ladies will be shown about the city and will be entertained at luncheon. The afternoon will be devoted to a second professional session.

The Thursday morning session will be held in Minneapolis in the buildings of the University of Minnesota. A representative of the University will make the opening address, and luncheon will be served. During the morning the ladies will be shown about the city in automobiles. In the afternoon the members of the Society and their guests will be entertained by Mr. Gebhard Bohn at his beautiful home on Lake Minnetonka. Supper will be served and dancing will follow.

Friday will be devoted to technical excursions. There is a prospect of a trip to Duluth, in which case it is recommended that the party leave at 2.30 p.m., arriving in Duluth at 7.00 p.m., where a reception will be tendered by the local members of the Society. An opportunity will be given next day to inspect the Duluth harbor with all its engineering features. It is hoped that boat connections will be such that members from the East may return by way of the Lakes.

A further suggestion is a trip to Keokuk to inspect the great water power plant on the Mississippi River.

CONSIDERATIONS AFFECTING THE PUBLICATION OF TRANSACTIONS

In the January issue of The Journal was an explanation of the plans, formulated by the Publication Committee and approved by the Council, for the development of The Journal, in which the proposal was made to include Transactions in The Journal, thereby avoiding the expensive and wasteful duplication which has resulted from the publication of matter first in The Journal and later in the annual volume of Transactions. Supplementing this, a statement is here given of the main considerations involved in this change.

At the outset it should be said that the publication plans have been so formulated that there will be ample opportunity to give them a thorough trial, and so determine their adaptability to the needs of the Society by actual experience. The volume of Transactions for 1913 will be issued as usual the coming summer and even if no action in the matter is taken until a year from the present date, a volume for 1914 can be published, if so ordered by the Council.

Five years ago the only meetings besides the sessions at the Annual and Spring Meetings were occasional meetings in New York. At that time it was possible to include in one annual volume of Transactions practically all the material presented before the Society. Since that time, however, there have been two important developments in the meetings of the Society, besides other activities, which have made a revision of the whole publication plan seem desirable.

Local meetings have been organized in twelve cities and last year forty such meetings were held. At many of these monthly meetings papers are contributed which are worthy of a place in the Society's publications. Almost none of these papers, however, can be published in Transactions because of the necessity for keeping within the limits of a single volume annually, the cost of a two-volume edition being prohibitive.

The other development has been the professional committees appointed by the Committee on Meetings. The need for these was made evident by an analysis of the papers contained in recent volumes of our Transactions which showed that certain subjects had received disproportionate attention, that others had been treated inadequately, and still others entirely neglected. Out of 685 papers, 71 were devoted to steam engines, while 82 subjects that were regarded as important in present-day engineering had not been discussed at all. Men of authority in these subjects were accordingly appointed to arrange meetings dealing with important phases of mechanical engineering not previously treated.

The result of this movement has been to broaden the interest in the Society and to increase the number of sessions and the number of papers presented, with corresponding benefit to the membership. It has added, however, to the publication problem, so that it has not only been necessary to omit reports of monthly meetings from Transactions, but to condense and even to omit some papers given at the Annual and Spring Meetings.

Another serious problem in this connection is the handling of the reports issued by the special committees of the Society. There are fifteen of these committees and their reports will constitute a large volume of material.

Members who are not in touch with this situation probably do not realize how much the developments mentioned enhance the value of the Society's publications when conducted in an economical and effective manner. For example, the Committee on Railroads has within a year held three sessions, at a single one of which fifteen papers were presented on the subject of Steel Cars, and at another one of which there was a comprehensive paper on Air Brakes, containing 200 pages. A short time ago the Boston Section held a convention at Worcester, at which several papers were given, and the New Haven Section holds quarterly meetings at each of which several papers are read. Simultaneous sessions at the Annual Meeting with more papers and more discussion are the regular thing; the local committee at San Francisco devotes its meetings to engineering practice on the Pacific slope; the committee at St. Paul and Minneapolis is now arranging for papers on engineering in the Northwest; the professional committees contribute their quota; and there are already in hand for publication two voluminous reports of 250 pages each, prepared respectively by the committees on Power Tests and Boiler Specifications. These instances are cited and many others could be given to show the broad scope of the matter now contributed to the Society and the large amount of material to be handled.

The Publication Committee, therefore, have had to determine how best to place at the disposal of the membership the vast quantity of material coming from these various sources. Transactions, as has been stated, has reached the point where the expense of its production in anything like complete form is prohibitive. The publication and distribution of papers in Transactions after they have appeared in The Journal is wasteful and uneconomic. Further, practice in the mechanic arts now changes with so much greater rapidity than at the time when this Society was founded that the value of papers and discussion is very much less by the time a member receives them in the volume of Transactions than it was at the time of their presentation. The value to the members of a separate volume of Transactions may also be questioned, and each member can answer this for himself by considering to what extent he consults his bound volumes or whether he is inclined to relegate them to an unused section of his bookcase.

Such considerations as the foregoing led the Pub-

lication Committee to make the following recommendations, which conform with the practice of an overwhelming majority of the societies of the world, in the following extract from their report for 1913, published in the December Journal:

The Committee believes that under present conditions the monthly publication of a great engineering society should be of much broader scope and that the reports of meetings and accounts of Society affairs in general should become the predominating features. The papers should be published in the numbers following a meeting, instead of in advance, enabling the papers and discussion to be brought together in the form of reports, and presented in the same manner in which any technical journal would deal with the affairs of the day. Under such an arrangement of papers and discussion not only would the value of The Journal to the membership be enhanced, but the arrangement would be such that it could take the place of Transactions.

In regard to the latter, the arguments in favor of issuing The Journal in such form that it will itself consist of the Transactions, thus making unnecessary the duplicate publication of part of the matter appearing in The Journal, are as follows:

1 The declining value to the average member of the Society of such a publication as Transactions, which at best covers but a narrow part of the broad expanse of the full activity of the Society, as compared with the increasing value of such a publication as The Journal, which besides doing just what the Transactions does, also covers every other activity of the Society.

2 The increasing cost of Transactions, due to the increase in editorial work necessary to reduce to the limits of one volume the large number of papers now being read all over the United States in the various branches of the Society as well as at the Annual Meetings. Should the alternative be adopted, namely of a two-volume edition, the cost would then be prohibitive.

3 The advantage to the membership of having these funds available for other and more useful purposes.

4 The elimination of the economic waste now incurred by publishing in two places the papers presented before the Society, a practice which has never been indulged in by the great European societies, and which is customary with only three other American societies.

It will be observed that what has been done is to arrange the matter in The Journal so that the papers and discussion will be brought together instead of being published in separate issues as heretofore. When published in this way they constitute the Transactions of the Society brought to the attention of the membershhip from month to month when the material is yet new and timely, instead of a year after it has been presented. With The Journal made to include the Transactions, it will become more valuable to the membership than were formerly The Journal and Transactions together, and the money saved by this arrangement can be put to much more useful purpose than in a duplicate publication of the papers and discussion presented at the meetings. The goal is greater efficiency, greater usefulness and better service.

COUNCIL NOTES

The members are invited to participate in the subscriptions now being made for a memorial to Sir William H. White, and a committee consisting of Jesse M. Smith, Chairman, F. R. Hutton, and Alex. C. Humphreys, was appointed at the meeting of the Council on February 13 to have charge of the matter. Sir William, who was an Honorary Member of the Society, was known personally to many of the membership.

The following committees were approved in local centers: Buffalo, W. H. Carrier, Chairman, Jas. W. Gibney, S. B. Daugherty, C. A. Booth, C. H. Bierbaum; Milwaukee, E. P. Worden, Chairman, F. H. Dorner, Secretary, Henry Weickel, H. Greger, L. P. C. Smith, H. V. Conrad; St. Louis, F. E. Bausch, Chairman, E. L. Ohle, Secretary, L. Nordmeyer, H. W. Hibbard, John Hunter; and in New York, John P. Neff in place of F. A. Waldron, whose term has expired.

Calvin W. Rice, *Secretary.*

PROFESSOR SWEET GIVEN DEGREE

It is a pleasure to record, as has been done in the personal column in this issue, the conferring of the degree of Doctor of Engineering by Syracuse University on Prof. John E. Sweet, one of those most instrumental in the founding of the Society.

Engineers have felt it an honor, whenever there was an opportunity, to express to Professor Sweet their appreciation of his long life of service, and this opportunity has now come to the University. The degree was conferred on Professor Sweet at his office in the works of the Straight Line Engine Company, where he was sought out by the representatives of the trustees and faculty of Syracuse University. The presentation was made by Dean Wm. P. Graham, who spoke of the notable services which Professor Sweet has rendered to the engineering profession and of the inestimable value of his friendly council to students, inventors, experimenters, and others seeking to gain recognition in various departments of mechanical activity. Professor Sweet responded characteristically, saying that it seemed as though his friends had been honoring him all his life.

ASSOCIATION OF TECHNICAL SECRETARIES

The Secretary of the Society attended a preliminary conference on February 7 of the secretaries of railroad and technical societies, and it is expected that there will shortly be issued a call for the secretaries of the principal technical societies to form an association which will serve principally as a clearing house for the dates of meetings and conventions, thus avoiding conflicts. It is possible also that this organization will secure other mutually helpful features.

PRIZES FOR TECHNICAL PAPERS

The Society is fortunate in having received from Mr. Henry Hess, member of the Council, an endowment of $2000, the income from which is to be used for prizes for technical papers from Junior and Student members. The awarding of prizes to young men rising in their profession has been recognized by many foreign societies as an incentive for the attainment of distinction, though to a less extent in this country, except in educational institutions.

Mr. Hess has conferred a great favor upon the Society by initiating a movement of this kind and by placing the funds in the hands of the Society without restrictions. The following resolutions were passed by the Council in acknowledgment of this generous gift:

Whereas, the Council of The American Society of Mechanical Engineers has heard with deepest appreciation the announcement of the gift to the Society from Mr. Henry Hess to establish two prizes for the best technical paper in any year in each of two classes in the membership, and

Whereas, the Council accepts these gifts with thanks and covenants to see that the generous and wise purposes of the donor shall be carried out,

Resolved, that a copy of this minute of appreciation and acceptance be engrossed and signed by the President and Secretary of the Society and transmitted to Mr. Hess, and

Resolved, that the Committee on Meetings be requested to confer with Mr. Hess as to the details of the competition, the standard of excellence and originality to be maintained and other features of the prize papers and to report their recommendations to the Council.

TWO IMPORTANT REPORTS

Two reports, involving many months of investigation and labor on the part of the committees of the Society having them in preparation, are now ready for the printer and will be ready for distribution within a few weeks.

These are the reports of the Committee on Power Tests and of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for the Care of Same in Practice. Each of the reports is voluminous and represents a large expenditure of time and painstaking effort, as well as the best thought of many engineers who are specialists upon the subjects involved.

The Power Test report, which contains rules for conducting performance tests of power plant apparatus, was published in preliminary form in The Journal, and brought up for discussion at the Annual Meeting of 1912. It has since been revised and to a considerable extent rewritten as the result of many helpful suggestions and criticisms offered by members of the Society, and is now ready to be printed in its final form and presented to the Council for approval.

The report of the Committee on Boiler Specifications is still in its preliminary state and a limited edition will be printed for immediate distribution. Copies will be sent to a selected list of engineers and their comments invited, so that the Committee may have before them the opinions of these men before putting their report into its permanent shape. It is expected that this report will be used in many States as a basis for model laws for licensing engineers and firemen and for boiler inspection, including rules for construction, installation and operation, based upon the most approved practice of the present time.

JOHN FRITZ MEDAL

At a meeting of the Board of Directors of the John Fritz Medal Fund Corporation, a minute of appreciation on the completion of Mr. Fritz's long and useful life of effective service to his profession and his country was placed on record, in which the influence of his achievements and character upon the duty of awarding the medal was emphasized. The recipient of the medal must have done something of value such as would commend itself to the clear-headed judgment and the kindly approval of the big heart of the man in whose honor the Board acted.

The wish and ambition of the Board of Award was further expressed that at no time should the award fall below the standard set in the lifetime of Mr. Fritz as respects the character of the men to whom the medal is to pass.

CORRESPONDENCE STATISTICS

One measure of the broad field covered by the Society's activities is the amount of mail received and sent out in the conduct of its work. The following statement of mail, express and freight received at and dispatched from its headquarters during the calendar year 1913 is of interest in this connection:

Incoming matter included 58,110 letters, 5400 packages and 3420 books and periodicals.

Outgoing matter included 113,287 letters, 53,607 circulars, 75,196 copies of The Journal, 4860 copies of Transactions, 6761 copies of the Year Book, 10,600 of the Geographical Lists of members, 11,500 copies of Condensed Catalogues, 3650 copies of professional papers, 393 miscellaneous volumes, and 5325 miscellaneous packages; a total of 285,179 separate pieces.

This statement does not include the very large volume of correspondence, notices, etc., received and dispatched by local sections, student branches, committees and officers of the Society directly from their own offices. Generous recognition should here be given to the many officers and members of committees who not only give largely of their time, but also substantial contributions of postage and stationery, clerical and stenographic services, traveling and office expenses. Although the Society maintains a large staff and spent during the last fiscal year nearly $120,000 in the ad-

ministration of its service to the membership and the profession, it could not possibly have covered so wide a sphere of work without this generous assistance from individuals and companies and the active participation of committees.

The statistics quoted give some conception, although not an adequate one, of the manner in which the Society keeps in touch with its members, sister societies, the diversified industries included in the field of engineering, as well as officials of city, state and nation, nor are these activities confined to the United States.

They reflect, moreover, the rapid development of the profession, in keeping with the industrial expansion of the country, and also to a large degree the increasing participation of the engineer in public affairs.

YEAR BOOK FOR 1914

The 1914 issue of the Year Book is now ready for distribution and will shortly be in the hands of the membership. It contains the names and connections of the 5394 members of the Society, arranged both alphabetically and according to geographical location. The volume contains also, as usual, a list of the officers and committees of the Society, some general information about the Engineering Societies Building and Library, the Constitution and By-Laws, and several other matters of like value to the membership at large.

Each member is entitled to receive free of charge a cloth bound copy of the Year Book, and if he desires additional copies may secure them at a cost of fifty cents apiece. Non-members may purchase copies at one dollar apiece.

LOCAL MEETINGS

It was not until the spring of 1909, when meetings of the Society were organized in St. Louis and Boston, that any local meetings were regularly held except at the Society's headquarters in New York. The remarkable growth in this direction during the past five years will be evident by noting the brief reports of meetings in this issue of The Journal and announcements of those to come. There were ten of these meetings reported, with a gratifying attendance. At Chicago a meeting and banquet were held, attended by 140; there were 100 in attendance at the Cincinnati meeting; 80 at San Francisco; and 40 at a St. Paul-Minneapolis meeting. In the matter of attendance the Boston Section has probably on the average had more engineers present than any other city. The quarterly meetings at New Haven have had a large attendance, that at the last one exceeding 250.

In stating the above only the figures at hand have been quoted to indicate the interest displayed at the various centers. Undoubtedly the attendance in other cities, as at St. Louis, may considerably exceed some of the figures mentioned. In most of these cities an effort has been made to bring together the engineers of different organizations holding joint meetings under the plan, usually, of having some one society in charge. The scope of these meetings and the valuable accessions to the literature of the Society which come as a result of this growing activity is clearly indicated by the following list of papers taken from the reports and announcements in the present issue: Boiler Tests with Illinois Coal, by Bryant Bannister, presented at the Chicago meeting, January 28; Air Conditioning, by J. Irvine Lyle, presented at St. Louis, February 4, and also at Cincinnati on February 12; American Railroad Ditcher, presented by Oliver Crosby at St. Paul on January 7; Construction and Mechanical Details of the Minnesota State Prison at Stillwater, by C. L. Pillsbury, read at Minneapolis on February 11; Transportation of Crude Oil in Pipe Lines, a symposium given at San Francisco on February 10; Business Training for Engineers, Dr. Alex. C. Humphreys and T. L. Jones, given at Philadelphia on February 9; Railroad Rolling Stock, Electrical Equipment and Permanent Way, symposium at Boston, February 4; Brake Performance on Modern Steam Railroad Passenger Trains, by S. W. Dudley, presented at New York, February 10; Color Photography, its Processes and Results, to be given at New York on March 10; Symposium on Welding, to be given at the Boston meeting of March 11; the Development of the Steam Plant of the Modern Electricity Supply Station, by I. E. Moultrop, announced for Philadelphia, March 14; and Safety Appliances in Industrial Plants, by John Price Jackson, Buffalo, March 12.

NINETIETH ANNIVERSARY OF RENSSELAER POLYTECHNIC INSTITUTE

Rensselaer Polytechnic Institute, the oldest technical college in America, celebrated its ninetieth anniversary on February 6, at a dinner at the Hotel Biltmore, New York, at which occasion was also taken to pay a tribute to the engineering profession. About 600 engineers, including members of the national engineering societies and the alumni of the various technical institutions of the country were present. Mr. Nelson P. Lewis of the Class of '79, engineer of the Board of Apportionment of New York, acted as toastmaster, and stated the conception of the occasion, drawing attention to the fact that the guests of honor were those representative of the engineering profession,—the presidents and secretaries of the five national engineering societies, and others prominent in the profession, including Alfred Craven, engineer of the public service commission of New York and its highest paid official; Elmer E. Corthell, prominent for work in connection with the jetties made at the mouth of the Mississippi under the direction of Mr. Eads, and for other remarkable harbor and river work in Central and South America; Richard C. Hollyday, representing the United States Navy;

Alex. C. Humphreys, Past-President of this Society and President of Stevens Institute of Technology; Robert W. Hunt, Past-President of this Society and prominent as a pioneer in the Bessemer steel industry of this country, and Alfred Noble, member of our Council, past-president of the American Society of Civil Engineers and Honorary Member of the Institution of Civil Engineers, and formerly a member of the Isthmian Canal Commission.

The principal address of the evening was given by Howard Elliott, chairman of the New York, New Haven and Hartford Railroad Company, which was a masterful tribute to the engineering profession. The other speakers were the Hon. Edward E. McCall, chairman of the Public Service Commission, Samuel Insull, president of the Commonwealth Edison Company of Chicago, Arthur B. Leach, banker and financial agent for many power development companies, Jean L. de Pulligny, director of the French Government commission of engineers to the United States, which is in the nature of a post-graduate course of instruction through travel for engineer graduates of French universities, and Palmer C. Ricketts, president of Rensselaer.

The whole occasion was one long to be remembered as in every way contributing to the encouragement of the engineer and the drawing of public attention to his responsibilities in all public affairs. Much of the credit for the success of the evening is due to Edwin N. Sanderson of the Class of '86, Chairman of the dinner committee.

INTERNATIONAL ENGINEERING CONGRESS

According to the latest report of the Committee of Management for the International Engineering Congress, to be held in San Francisco in 1915 under the auspices of the five national engineering societies, the official invitation to participate in the Congress has been accepted by 173 societies in all parts of the world, and many others yet to be heard from will doubtless send delegates. The Congress will thus offer an exceptional opportunity to all who attend to meet the leading engineers of this country and of other nations, and should be one of the most representative gatherings of the engineering profession ever held in America.

The meetings of our Society abroad in 1910 and during the past summer impressed the membership particularly with two features—the solidarity of the engineering profession in Europe, and the important position held by engineers in public affairs. Such a Congress as that of 1915, held in conjunction with the celebration of the greatest engineering achievement of our country, should form the occasion of acquainting the public with the part of the engineer in the world's work.

As one of the five organizations under whose auspices the Congress is to be held, members of the Society have been asked to enroll as members of the Congress, and thus far 223 have responded. The American Society of Civil Engineers heads the list with an enrollment of 296, the American Institute of Electrical Engineers having 185, the American Institute of Mining Engineers 34 and the Society of Naval Architects and Marine Engineers 18. It is hoped that many more of our members will enroll at an early date, so that we may not fall behind the good proportion that is customary in an affair of such importance and opportunity.

At the last meeting of the Council it was formally voted to appoint a committee to consider and make comprehensive recommendations in regard to the entertainment of the foreign engineers who will attend, as the Society looks forward with much pleasure to renewing the friendships formed in the recent trips abroad.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i. e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are under twenty-five years of age and therefore qualified for Junior grade only. The Membership Committee and in turn the Council urge the members to assume their share of the responsibility of receiving these candidates into the membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before April 10, 1914.

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ARMSTRONG, WM. H., Mgr., Pneumatic Tool Dept., Ingersoll-Rand Co., New York.

BENNETT, ROBERT G., Inspector, Test Dept., Penna. R. R., Altoona, Pa.

BILLOW, CLAYTON O., Cons. Engr., Secy. and Treas., National Supply Co., Chicago, Ill.

BLACK, WINFIELD S., M.M., American Sugar Refinery, Brooklyn, N. Y.

BOWEN, ALMON F., Mech. Engr. Glamorgan Pipe & Foundry Co., Lynchburg, Va.

BOYD, WILLARD A., Cons. Engr., 22 Pendleton Pl., New Brighton, N. Y.

BRETZFELDER, IRA L., Vice-Pres. and Treas., Alvey Mfg. Co., St. Louis, Mo.

BUEDINGER, OTTO, Water Filtration Expert, Birmingham, Ala.

Burnett, R. W., Genl. M.C.B., Canadian Pacific Railway, Montreal, P. Q.

Cade, Charles W., Genl. Supt., The Crown Cork & Seal Co., Baltimore, Md.

Clark, David B., Engr., Railway Materials Co., Chicago, Ill.

Clifford, Ernest L., Engr. with William A. Pope, Contractor, Chicago, Ill.

Cook, Robertson, Prof. Experimental Engrg., South Dakota State College, Brookings, S. D.

Copeland, Frederick K., Pres., Sullivan Machinery Co., Chicago, Ill.

Criqui, Albert A., Htg., Vent. and Fan Engr., Buffalo Forge Co., Buffalo, N. Y.

Cromwell, Oliver C., Mech. Engr., The Baltimore & Ohio R.R. Co., Baltimore, Md.

Dunlop, William C., Asst. Elec. and Mech. Engr., Barclay, Parsons & Klapp, New York.

Flateboe, Einar I., Ch. Engr., The Vulcan Iron Works, Seattle, Wash.

Gilmore, John W., Vice-Pres. and Factory Mgr., Crouch & Fitzgerald Co., New York.

Graffam, Walter S., Instr., Smith's Agri. Sch. & Northampton Sch. of Industries, Northampton, Mass.

Harris, Carl C., Supt., Rodney Hunt Machine Co., Orange, Mass.

Haswell, Wm. E., Secy., Ohio Board of Administration, Columbus, O.

Hatch, Henry J., Turbine Engr., General Elec. Co., Lynn, Mass.

Hearn, George, Pres., The Ricker Mfg. Co., Rochester, N. Y.

Henry, Alexander S., Vice-Pres., Railway Steel Spring Co., New York.

Hindman, Wilbert L., Rate Setter, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Howard, Frank E., Secy. & Treas., James L. Howard & Co., Hartford, Conn.

Hughes, Richard H., Vice-Pres. & Genl. Mgr., Crescent Portland Cement Co., Wampum, Pa.

Johnson, Henry S., Babylon, L. I.

Jones, Edward A., Pres. and Treas., E. D. Jones & Sons Co., Pittsfield, Mass.

Keller, Albert T., Mech. Engr., Indiana Steel Co., Chicago, Ill.

Kelly, Andrew, Supt., Newark Stations, Public Service Elec. Co., Newark, N. J.

King, Edwin L., Receiver, The Pratt & Cady Co., Hartford, Conn.

Lasher, George W., Asst. Treas. & Mgr., Munson Bros. Co., Utica, N. Y.

Mansfield, Julian B., Ch. Engr., Vice-Pres. & Genl. Mgr., The J. E. Bolles Iron & Wire Wks., Inc., Detroit, Mich.

Maxfield, Daniel E., Supt., Florence Iron Works, Florence, N. J.

Mehl, Walter B., Pres., Mehl Machine Tool & Die Co., Garwood, N. J.

Merrian, Pearl E., M. M. Methuen Co., Methuen, Mass.

Morss, Everett, Pres., Simplex Wire & Cable Co., Boston, Mass.

Morrell, Alfred M., Mgr., Drop Forging Dept. & Purchasing Agt., Spicer Mfg. Co., Plainfield, N. J.

Neely, Frank H., Factory Mgr. with Harry L. Schlesinger, Atlanta, Ga.

Newbold, Charles E., Ch. Engr. and Factory Mgr., Havana Iron Wks., Krajewski-Pesant Corp., Talleres de Pesant, Regla, Havana, Cuba.

Nichol, George A., Jr., Eastern Asst. Mgr., H. W. Johns-Manville Co., New York.

Obert, Casin W., Pres., Atlantic Machine Co., Brooklyn, N. Y.

Press, Wm. J., Mech. Engr., Natl. Transcontinental Rwy. of Canada, Ottawa, Canada.

Rhys, Cyril O., Designer, The Diamond Match Co., Barberton, Ohio.

Richardson, Clifford T., Asst. Mgr., Constr. & Engrg. Dept., Swift & Co., Boston, Mass.

Rogers, Nathan S., Ch. Engr., Venice Power Station, Illinois Traction System, Venice, Ill.

Ruebel, C. A. Ernst, Pres., Ruebel & Wells, Consulting Engineers Co., St. Louis, Mo.

Sawtelle, Edmund M., Cons. Engr., 5 Beekman St., New York.

Schoof, Arthur W., Asst. Supt., Wells Bros. Co., Greenfield, Mass.

Seed, Charles R., Supt. of Power, Worcester Elec. Light Co., Worcester, Mass.

Seib, George A., Mech. Supt., Remington Typewriter Wks., Ilion, N. Y.

Smart, Charles E., Efficiency and Mech Engr., Greenfield Tap & Die Corp., Greenfield, Mass.

Spilsbury, Raymond G., Engr. and Designer, John Robertson & Co., Brooklyn, N. Y.

Sinsheimer, Sidney W., Vice-Pres. and Genl. Mgr., The Holley Sugar Co., Denver, Colo.

Stone, Charles A., Member of Firm, Stone & Webster, Boston, Mass.

Storrs, Lucius S., Pres., The Connecticut Co., New Haven, Conn.

Suter, John H., Ch. Mech. Engr., Doe Run Lead Co., Rivermines, Mo.

Teetsell, Harry F., Genl. Supt., The Waldorf Box Board Co., St. Paul, Minn.

Tuttle, Henry A., Ch. Engr., Evans Stamping & Plating Co., Taunton, Mass.

Van Alstyne, David, Pres., Quigley Furnace & Foundry Co., New York.

Van Brunt, John, Genl. Mgr. and Ch. Engr., The American Stoker Co., New York.

Van Stone, Charles, Vice-Pres., Lunsden & Van Stone Co., Boston, Mass.

Vassar, Hervey S., Laboratory Engr., Public Service Elec. Co., Newark, N. J.

Vedder, John N., Asst. Engr., Experiment Sta., Univ. of Ill., Urbana, Ill.

Webster, George A., Supt., Star Brass Mfg. Co., Somerville, Mass.

Wharton, James R., Gas and Refrig. Engr., University of Missouri, Columbia, Mo.

Wilson, Jacob D., Pres. and Genl. Mgr., American Elevator Co., New York.

Wilson, James W., Supt., Lawer Depts., National Wks., National Tube Co., McKeesport, Pa.

Williams, Tracy B., Mch. Tool Designer, The Winton Motor Car Co., Cleveland, Ohio.

Ziegler, Leslie I., Mgr. Milling Mchy. Dept., Nordyke & Marmon Co., Indianapolis, Ind.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Gibert, Ralph W., Salesman and Demonstrator, Cincinnati Milling Machine Co., Cincinnati, Ohio.

Haley, Harry S., Member of Firm, Leland & Haley, San Francisco, Cal.

Haney, Jiles W., Research Fellow, Engrg. Experiment Station, University of Missouri, Columbia, Mo.

Horton, Theodore A., Shop Supt., John T. Horton Co., New York.

Somerville, William A. S., Engr., The B. F. Goodrich Co., Akron, Ohio

Strauss, William O., Adv. Mgr., Engr., The R. K. LeBlond Machine Tool Co., Cincinnati, Ohio.

Workman, LeRoy V., Steam Engrg. Dept., Cambria Steel Co., Johnstown, Pa.

Worthington, Edward H., Sales Engr., Power Specialty Co., Chicago, Ill.

FOR CONSIDERATION AS JUNIOR

Anderson, Wm. E., Designer, Alberger Pump & Condenser Co., New York.

Banfield, Stanley M., 6 Hackfeld Road, Worcester, Mass.

Barton, Charles R., Asst. Mech. Engr., Compania Mexicana de Petroleo "El Aguila," S. A., Tampico, Mexico.

Beerbaum, Arthur J., Draftsman, The Arnold Co., Chicago, Ill.
Burford, Robert A., Jr., Salesman, Power Equipment Co., Boston, Mass.
Dunning, David T., Sales Engr., Albro Clem Elev. Co., Philadelphia, Pa.
Farmer, Kenneth V., Cadet Engr., United Gas Improvement Co., Philadelphia, Pa.
Gillam, William H., Jr., Asst. to Genl. Mgr., James Boyd & Bros., Inc., Philadelphia, Pa.
Halsey, William D., Asst. Mech. Engr., The Sharpless Separator Co., West Chester, Pa.
Herrcke, Ernest A., Asst. Mgr., La Salle Machine & Tool Co., La Salle, Ill.
Hunter, Herbert C., Engr., Otis Elevator Co., Harrison, N. J.
Lukens, William P., Mechanic, Saxon Motor Car Co., Detroit, Mich.
MacDowell, Francis M., Draftsman, Power Specialty Co., Dansville, N. Y.
Ordway, Earl P., Ch. Draftsman, Union Steam Pump Co., Battle Creek, Mich.
Pfeiffer, Bernard V., Supt. of Mfg. and Distributing, Nashville Gas & Heating Co., Nashville, Tenn.
Robinson, Arthur S., Inspector, N. Y. Connecting R.R., Winfield, L. I., N. Y.
Robinson, Parker M., Draftsman, Southern Pacific Co., New York.
Shiland, Finley H., Engr., Chester Paper Co., Chester, Pa.
Snyder, James R., Cadet Engr., Cayadutta Generating Co., Fonda, N. Y.
Wentzell, Horace K., Ch. Tool Designer, Maxwell Motor Co., Detroit, Mich.
Wood, Alan A., Sales Engr., Builders Iron Fdry., Providence, R. I.

TRANSFER FROM ASSOCIATE

Gibson, George H., Cons. Engr., Prop., George H. Gibson Co., New York.
Jurgensen, Jess C., Genl. Supt., United Piece Dye Works, Lodi, N. J.

PROMOTION FROM JUNIOR

Ashley, Edward E., Jr., Mech. Engr., Starrett & Van Vleck, New York.
Conlee, George D., Supt., Chuctanunda Gas Light Co., Amsterdam, N. Y.
Fessenden, Edwin A., Associate Prof. Mech. Engrg., University of Missouri, Columbia, Mo.
Hollmann, Frederick W., M.M., Maryland Steel Co., Sparrows Point, Md.
MacMaster, Ronald K., Executive Dept., Am. Soc. M. E., New York.
Merrill, Albert S., Asst. to Ch. Engr., Turner Construction Co., New York.

SUMMARY

New applications	101
Transfer from Associate	2
Promotion from Junior	6
Total	109

UNITED ENGINEERING SOCIETY

REPORT OF TREASURER

To the Board of Trustees

United Engineering Society

I beg to submit herewith the report of your Treasurer as of December 31, 1913.

FINANCES

The Balance Sheet submitted herewith shows the physical property of the United Engineering Society, over and above the value of the building and the equity in the land, to consist of building equipment of a value of $27,357.16, furniture and fixtures $5,795.46, and library books $329.07.

There was added to the furniture and fixtures account during the year 1913 an amount representing an expenditure of $390.96, the principal items of which are: Drapery and hangings, alcove room $150.66, asbestos booth for moving pictures $70, filing cabinet $50.70, and three perforated rubber mats $48. In accordance with a resolution of the Board of Trustees, 10 per cent depreciation was charged off this account for the year 1913.

The principal of the mortgage on the land held by Andrew Carnegie, Esq., amounting originally to $540,000, has been reduced by payments from the land and building funds of the Founder Societies to $88,000. Payment of $40,000 was made during the year by the American Institute of Mining Engineers.

The present balances due from the societies are as follows: American Institute of Electrical Engineers $54,000, and American Institute of Mining Engineers $34,000. The American Society of Mechanical Engineers has paid the full amount of its indebtedness.

The gross operating expenses for the year 1913 were $38,981.54 as compared with $47,602.71 for the preceding year, showing a decrease of $8,621.17. During the year 1913 there has been very little expenditure of an unusual nature. The following are the principal items:

Storm doors, ground floor	$220.00
4 metal doors, ground floor	200.00
Additions to heating and ventilating	250.00
2 bookshelf cases (reimbursed by A.I.E.E.)	930.00
Painting interior	239.45
Taking down partitions Room 703, refitting in Room 901	245.75
Removing partition 11th floor (reimbursed by A.S.M.E.)	64.78
500 copies of By-Laws	156.14

In accordance with a resolution of the Board at a meeting held on January 23, 1913, an appropriation of $5000 was made out of the surplus for the year 1912, and of this amount $4943.75 was invested in $5000 New York City 4¼ per cent Corporate Stock, repayable 1962 at 98-13/16 as an addition to the Contingency and Renewal Fund, as provided for in the Founders Agreement, bringing the amount of said Fund to $29,963.75.

The assessments paid for the year by the Founder Societies, each occupying an entire floor, were $3375, representing as last year a total expenditure by each Founder Society, including interest on its full principal of mortgage on land of $10,575, reduced in each case to the extent the Society may have paid off part

or all of its mortgage share. The Associate Societies are assessed approximately $10,000 for equivalent privileges, which shows that the Founder Societies still meet a little more than their proportion of the carrying charges for equivalent office space occupancy in the building.

BUILDING

Equipment. The Real Estate Equipment Account during the year 1913 has been increased to an extent of $732.44, expended mainly in changes to north side of foyer on ground floor, sliding doors to create new room and architects services in connection therewith, also bookstacks on the twelfth floor.

Office Occupancy. There was on January 1, 1913, no unoccupied floor space (devoted to office space) in the building. There are, however, two rooms on the twelfth floor used during the past year for storage purposes from which no income has been received. There are now sixteen associate societies occupying office space in the building.

Meetings or Lectures. The record of the number of times the rooms were used during 1913 for meetings or lectures (not for office occupancy) is:

Meeting Room	Number of Times Occupied		
	1912.	1913.	Change.
Auditorium, 3rd and 4th floors	46	69	23 more
No. 1 Assembly Room, 5th floor	39	56	17 more
2 Assembly Room, 5th floor	70	129	59 more
3 Assembly Room, 5th floor	33	101	68 more
5 Lecture Room, 6th floor	35	10*	25 less
8 Lecture Room, 6th floor	84	20*	64 less
Small Committee Room, 2nd floor	12	0*	12 less
Small Committee Room (off foyer) 1st floor	0	10	10 more
Assembly Room 1201, 12th floor	0	18	18 more
Total	319	413	94 more

* No. 5 and No. 8 Lecture Rooms are now occupied by the American Museum of Safety, and the Small Committee Room on the second floor used as a storage space by the National Electric Light Association. Room No. 1201 was occupied last year by the Efficiency Society.

During the year 1913 the facilities of the building were enjoyed by 56 societies holding a total of 309 meetings, with an attendance of 63,348 as contrasted with 60 societies holding 253 meetings with an attendance of 42,324 during 1912.

LIBRARY

During the year 1913 there was added to the Library of the three Founder Societies and United Engineering Society 3566 volumes and pamphlets, of which 762 volumes and pamphlets were purchased at a cost of $2,078.04. The total number of books and pamphlets in the Library at the end of the year is 54,245.

The attendance during the year was 11,091 as compared with 10,522 during 1912, an increase of 569 for the year 1913.

The Department of Research Work has continued its activity during the past year. In answer to requests received from correspondents in Patagonia, Korea, Japan, Australia, Mexico, South Africa, the Congo Free State, Alaska, Canada, and England, as well as from different parts of the United States, 168 searches have been made on a great variety of subjects. These searches have included the making of several hundred photographic reproductions. More than a thousand reference questions have been answered at the desk.

The Library receives more than 800 technical periodicals which are available through indexes for research purposes.

Respectfully submitted,

(*Signed*) Jos. Struthers, *Treas.*

UNITED ENGINEERING SOCIETY

Balance Sheet, January 1, 1914.

ASSETS

Real Estate, Land		$540,000.00
Real Estate, Building		1,050,000.00
Real Estate, Equipment		27,357.16
Furniture and Fixtures		5,795.46
New York City Bonds, 4½% 1917	Depreciation Fund.	5,231.25
New York City Bonds, 4¼% 1930-60		5,062.50
New York City Bonds, 4¼% 1962		4,943.75
Baltimore & Ohio Bonds		5,037.50
Delaware & Hudson Company Bonds, 4% 1943		4,933.75
Southern Railway Bonds, 4% 1956		4,755.00
Library Books, U.E.S.		329.07
Library Adjustment Account		46.75
Accounts Receivable		4,564.18
Unexpired Insurance		960.83
Cash:		
Working Balance	$16,446.20	
For Contingency, Depreciation	10,000.00	
Ways and Means Committee	1,165.08	
		27,611 28
Petty Cash		500.00
Interest Receivable		680.00
		$1,687,808.48

LIABILITIES

Balance of Land Mortgage, A.I.E.E.	$54,000.00	
Balance of Land Mortgage, A.I.M.E.	34,000.00	
		$88,000.00
A.I.E.E. Equity in Building		350,000.00
A.S.M.E. Equity in Building		350,000.00
A.I.M.E. Equity in Building		350,000.00
A.I.E.E. Equity in Real Estate Equipment		3,346.61
A.S.M.E. Equity in Real Estate Equipment		3,346.62
A.I.M.E. Equity in Real Estate Equipment		3,346.62
A.I.E.E. Payments to date in liquidation of mortgage on land		126,000.00
A.S.M.E. Payments to date in liquidation of mortgage on land		180,000.00
A.I.M.E. Payments to date in liquidation of mortgage on land		146,000.00

For Contingency and Depreciation	40,000.00
Ways and Means Committee	1,165.08
Library Adjustment Accounts	75.45
Accounts Payable	1,070.14
Surplus Account	45,457.96
	$1,687,808.48

STATEMENT OF RECEIPTS AND DISBURSEMENTS, YEAR ENDING DECEMBER 31, 1913

CASH RECEIPTS

Balance on hand January, 1913	$13,541.76
Account of Interest on Mortgage	3,240.00
Assessment on Societies, Offices, Meetings, etc.	64,507.64
Library Account	8,175.27
Interest on Bonds and Deposits	1,783.76
A.I.M.E. in Reduction of Mortgage	40,000.00
	$131,248.43

DISBURSEMENTS

Account of Interest on Mortgage	$3,920.00
Account of Real Estate Equipment	732.44
Operating Expense, Cash Expenditures	38,035.40
Furniture and Fixtures	317.21
Library Account	8,175.27
Bonds Purchased (Contingency and Depreciation Fund)	4,943.75
Accrued Interest on Bonds Purchased	104.48
Accounts payable	2,024.56
A.I.M.E. Office Space Released	4,084.00
Insurance	632.62
Library Adjustment	667.42
Payment in reduction of mortgage	40,000.00
Balance on hand, January 1, 1914	27,611.28
	$131,248.43

OPERATING INCOME AND EXPENSES, YEAR ENDING DECEMBER 31, 1913

INCOME

Assessment Societies	$41,300.75	
Less: Refund for office space released	3,435.00	
		$37,865.75
Assessment Miscellaneous (Offices and Meetings)		12,707.50
Telephone Returns		4,836.68
Miscellaneous Charges to Societies		3,622.17
U.E.S. Library Returns		130.25
Interest		1,679.28
		$60,841.63

EXPENSES

Operating Expenses—Gross	$38,981.54
Contingency and Depreciation	10,000.00
Insurance	1,034.48
Depreciation on Furniture and Fixtures	600.50
Balance carried to Surplus Account	10,225.11
	$60,841.63

COMPARATIVE TESTS OF THREE TYPES OF BEARINGS

BY CARL C. THOMAS,[1] BALTIMORE, MD.

Member of the Society

E. R. MAURER[2] AND L. E. A. KELSO,[3] MADISON, WIS.

Non-Members

THIS paper, here published in abstract, reports experiments made to determine the absolute and relative amounts of power required to drive a series of uniformly loaded and flexibly connected shafts supported successively by 20 ring-oiled babbitt bearings, then by 20 roller bearings, and finally by 20 ball bearings. A great range of loads and speeds was covered, and coefficients of friction were worked out for each type of bearing. The apparatus was designed and built in the department of steam and gas engineering at the University of Wisconsin, in collaboration with the manufacturers of the bearings, and was so arranged that very exact measurements of power were attainable. All questions of possible lack of alignment, non-uniformity of loading, temperature and quality of lubricant, etc., were given careful study, resulting in the special form of apparatus used. The tests extended over four years, and were finally repeated and all results checked by a set of skilled observers who had formerly had no connection with the work.

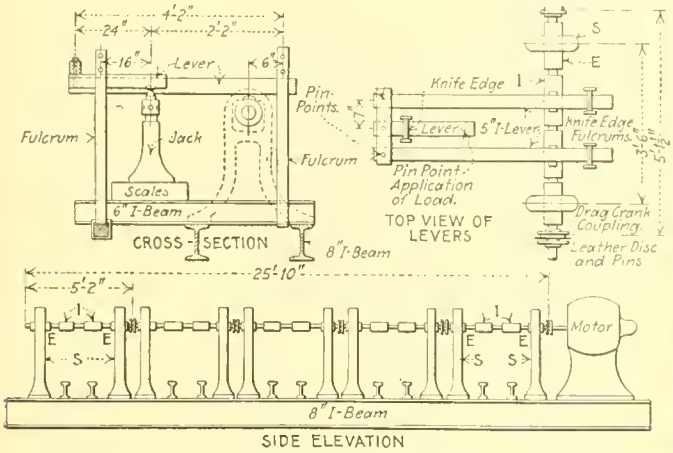

FIG. 1 APPARATUS FOR TESTING LINESHAFT BEARINGS

DESCRIPTION OF APPARATUS

The apparatus consists of 25 ft. 10 in. of lineshafting in five equal sections, mounted in hangers S which were inverted and used as floor stands, (see Fig. 1). The hangers were bolted to two 8-in. I-beams. The shafts are of cold rolled steel, 2 7/16 in. in diameter. Each section is 5 ft. 2 in. long; the adjacent sections were coupled together by means of a flexible leather disk or two straps connecting the two flange couplings. The flexible couplings prevented transmitting any part of the load applied on one shaft to either adjoining section, and also prevented binding between shafts and bearings due to possible lack of alignment.

A direct-current Fort Wayne motor is directly connected to one end of the shafting by means of a flexible coupling. The motor is of the interpole type with the interpoles removed, making it a shunt motor. A water rheostat is used in the field circuit to maintain a constant field, and another water rheostat is used in the armature circuit to vary the speed by varying the impressed voltage. The lost power was obtained first by taking the armature resistance for various currents and plotting a resistance, armature-current curve. From this curve was plotted an armature-I^2R loss, armature-current curve. From this the armature resistance loss for any armature current was obtained. The stray-power loss was obtained by taking a stray-power loss, field current curve for each speed. Then for any speed the loss for that speed and field could be obtained. By use of this method the power required to run the motor alone at all speeds, without load, was accurately ascertained, as well as the power required to run the motor and shafts together, at all loads and speeds. The relative amounts of power required to overcome the friction of the various types of bearings were therefore accurately determined.

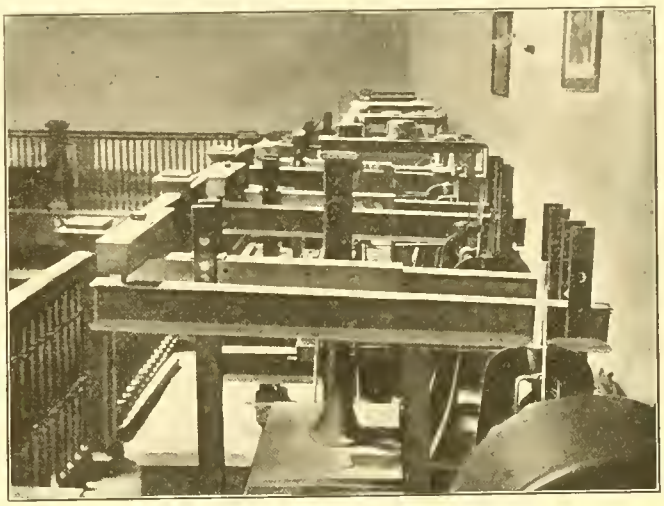

FIG. 2 VIEW SHOWING METHOD OF LOADING BEARINGS

[1] Professor of Mech. Engrg., Johns Hopkins University.
[2] Professor of Mechanics, University of Wisconsin.
[3] Instructor in Elec. Engrg., University of Wisconsin.

Presented at the Annual Meeting, 1913, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Pamphlet copies of the complete paper may be obtained: price, 15 cents to members, 30 cents to non-members.

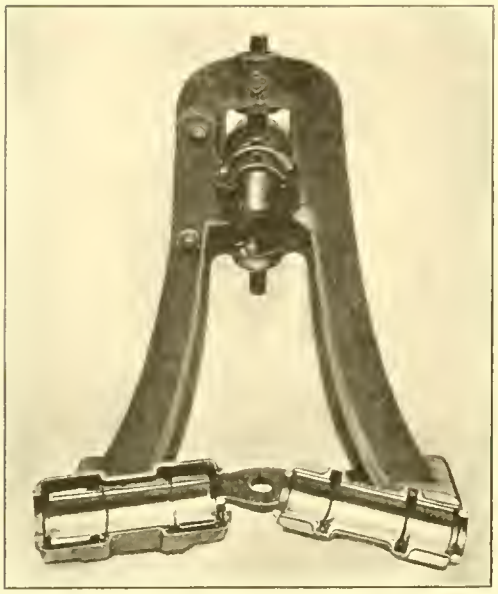

Fig. 3 Type of Ring-Oiled Babbitt Bearing used in Tests

The load was applied through levers upon hardened knife edges and pin points as fulcrums. Across the top of the 8-in. I-beams and at right angles to them were bolted short 6-in. I-beams to which the fulcrums were attached, Figs. 1 and 2.

The loads were applied to the shaft by two bearings between each pair of hangers. These bearings are identical with those in the hangers, and are supplied with knife edges which engage a V-shaped groove in the 5-in. I-beam levers. The bearings and hangers for each section were symmetrically placed with respect to the middle of the section; therefore, equal loads on the intermediate bearings *I*, produced equal pressures on the end bearings *E*. These latter pressures exceeded those on the intermediate bearings by one-half the weight of the shaft, or by 40 lb. This difference is regarded as negligible in the paper, and load per bearing means average of the loads on intermediate and end bearings. The bearings were prevented from turning by short levers fastened to the bearings and resting upon uprights from the floor. Only one type of bearing was tested at a time, so that no complications might arise in establishing the losses for the particular bearing under test. The reason for using 20 bearings was that the amount of power necessary for a single bearing was so small as to be difficult of exact measurement. Also any single bearing might not as truly represent results from that type of bearing in general as several bearings taken together.

The three kinds of bearings tested were: the ring-oiled bearing manufactured by The Dodge Manufacturing Company lined with babbitt metal made from their formula; the Hyatt roller bearing manufactured by the Hyatt Roller Bearing Company; and the Hess-Bright ball bearing manufactured by the Hess-Bright Manufacturing Company. All bearings were for the same size shaft and in fact the same pieces of shafting were used for all the tests, except that two sections which bent during the tests were replaced.

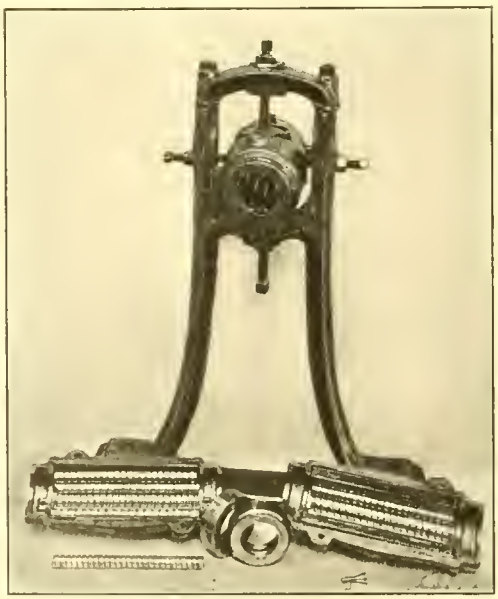

Fig. 4 Type of Roller Bearing used in Tests

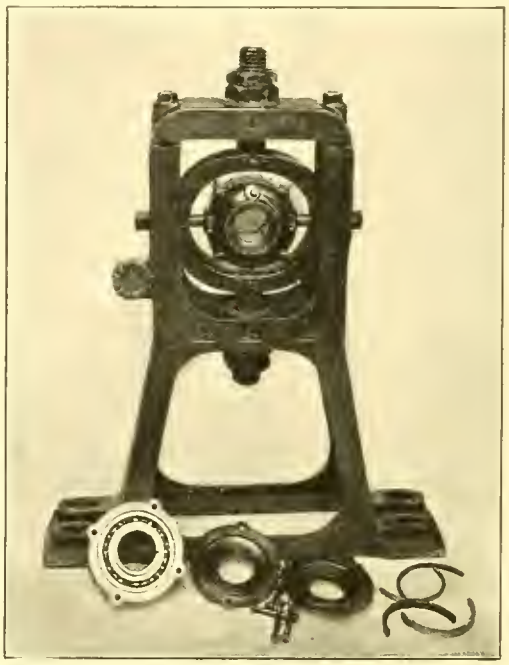

Fig. 5 Type of Ball Bearing used in Tests

The babbitt bearings are 9 $^{21}/_{32}$ in. long and hence their projected area is 22.36 sq. in. The following table is appended here for converting total loads used in the tests into unit loads:

730	1230	1730	2230 lb. per bearing
33	55	78	100 lb. per sq. in.

These bearings were oiled by the well-known ring oiler device, two rings in each bearing.

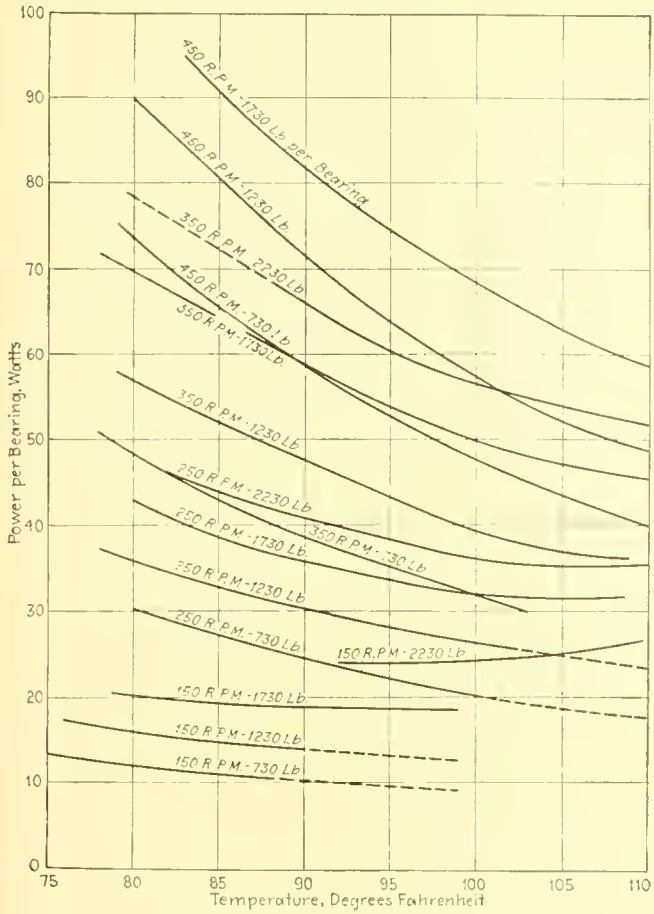

FIG. 6 BABBITT BEARINGS. POWER-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

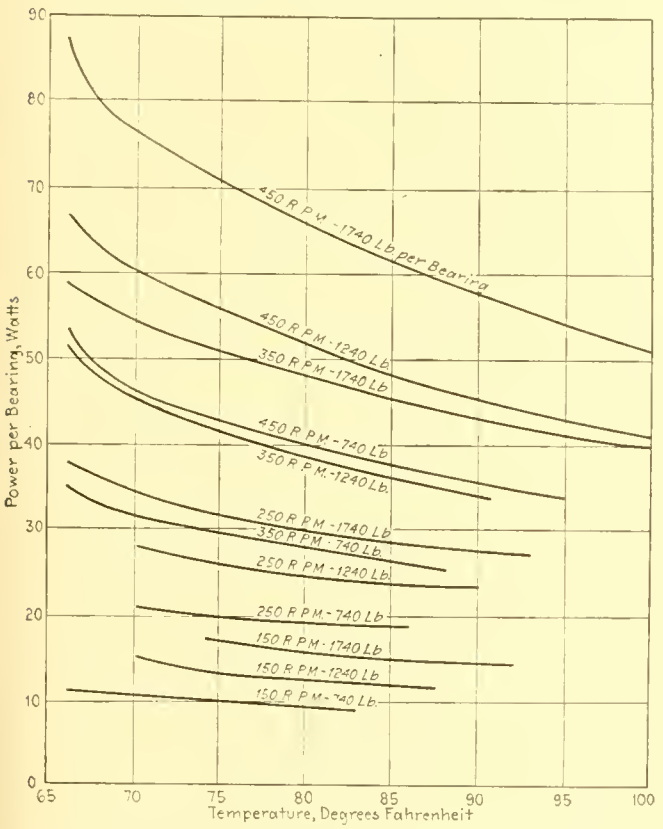

FIG. 7 ROLLER BEARINGS. POWER-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

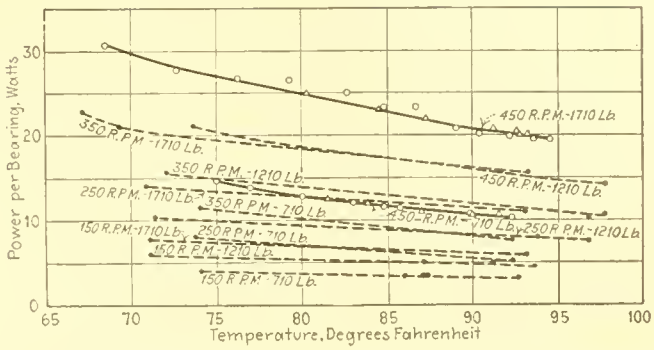

FIG. 8 BALL BEARINGS. POWER-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

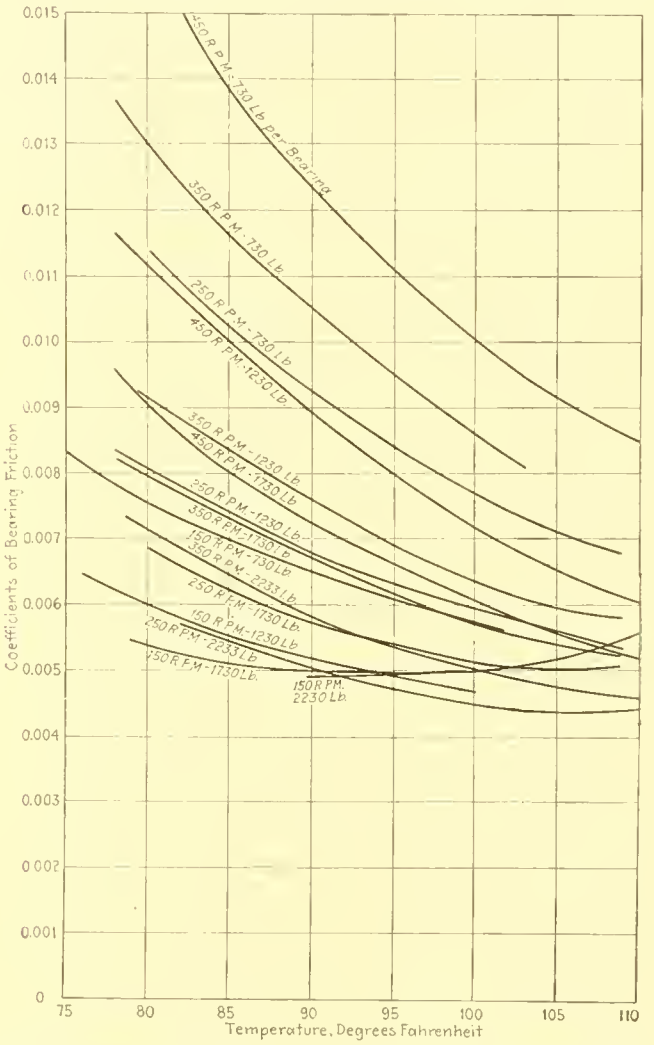

FIG. 9 BABBITT BEARINGS. COEFFICIENT OF FRICTION-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

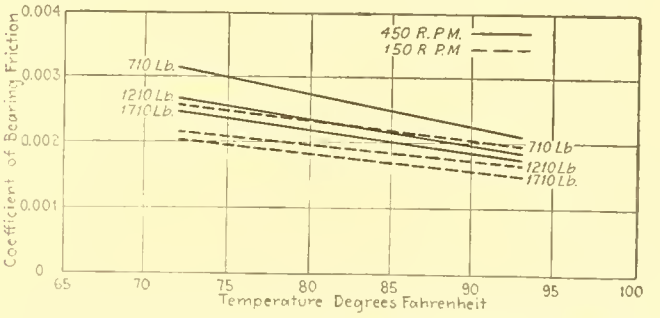

FIG. 10 BALL BEARINGS. COEFFICIENT OF FRICTION-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

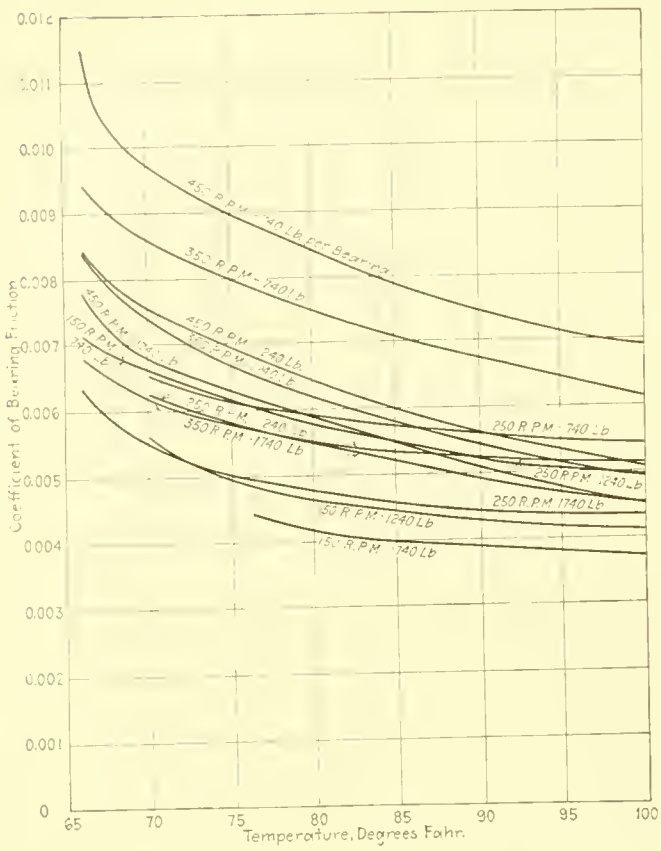

FIG. 11 ROLLER BEARINGS. COEFFICIENT OF FRICTION-TEMPERATURE CURVES FOR VARIOUS SPEEDS AND LOADS PER BEARING

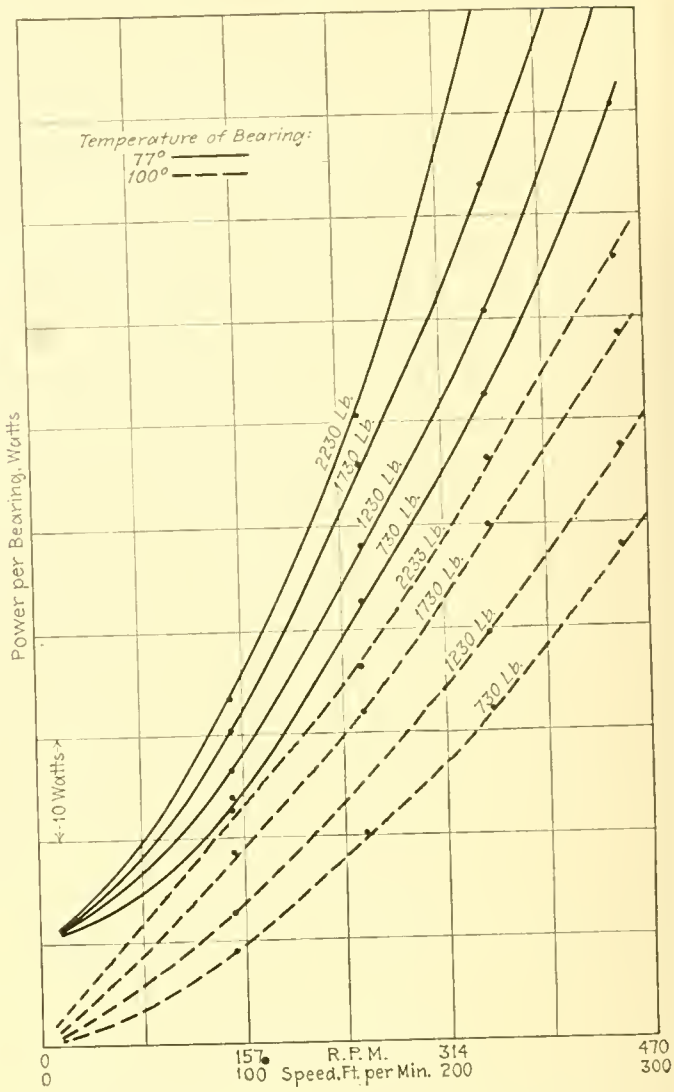

FIG. 13 BABBITT BEARINGS. POWER-SPEED CURVES FOR VARIOUS LOADS PER BEARING

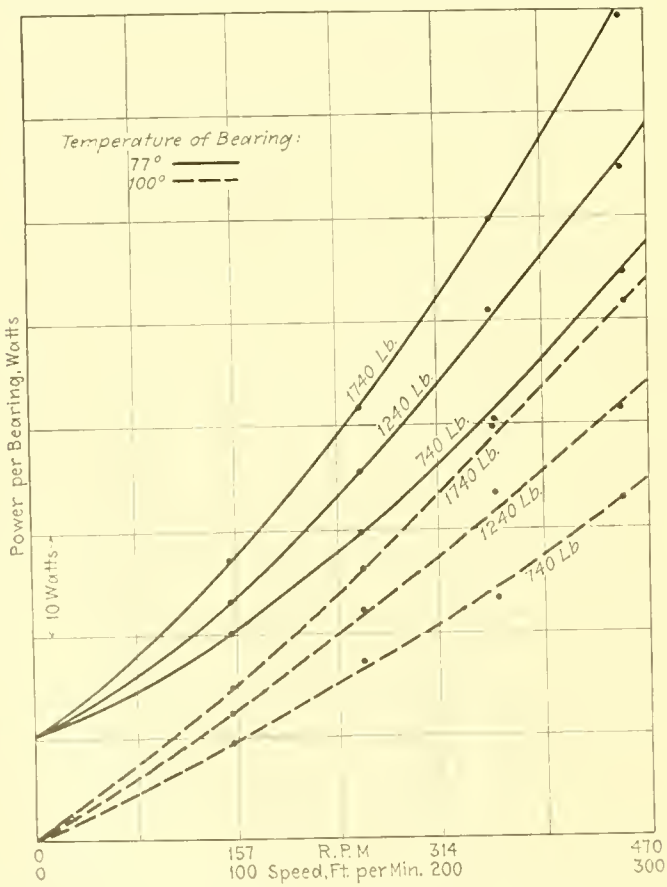

FIG. 12 ROLLER BEARINGS. POWER-SPEED CURVES FOR VARIOUS LOADS PER BEARING

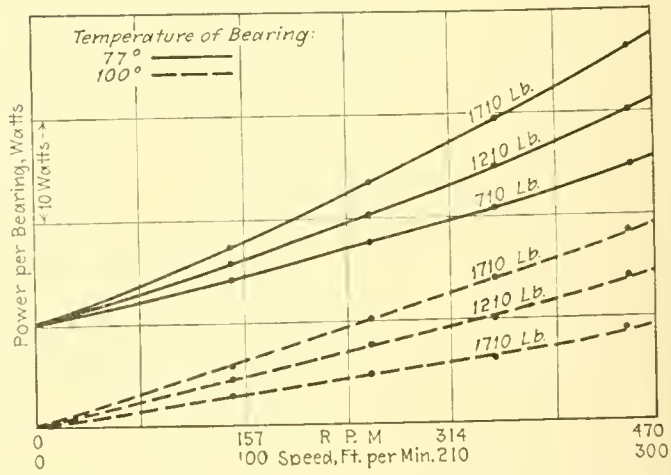

FIG. 14 BALL BEARINGS. POWER-SPEED CURVES FOR VARIOUS LOADS PER BEARING

Each roller bearing contains six right-hand and six left-hand rollers, 0.780 in. in diameter; six are 9 9/16 in., and six are 9 3/16 in. long. The bearings are of the type in which a cage is used for holding one-half the rollers. Each ball bearing contains a single set of balls 9/16 in. in diameter. The diameter of the inner race through ball groove is 3.4729 in. The three types of bearing are shown in Figs. 3, 4 and 5.

The power was measured by the ammeter voltmeter method. Mercury thermometers (two in each babbitt

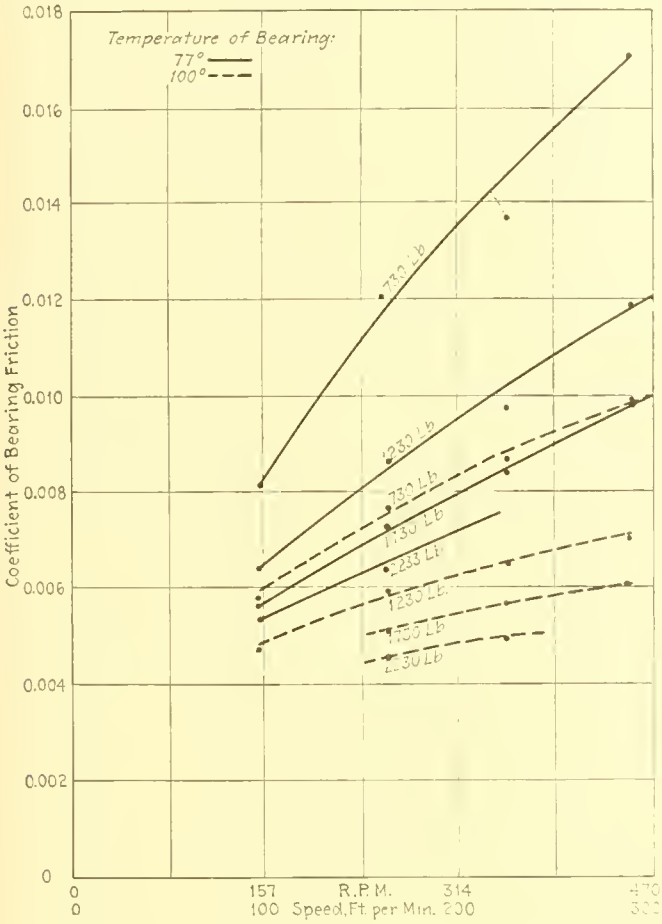

Fig. 15 Babbitt Bearings. Coefficient of Friction-Speed Curves for Various Loads per Bearing

and roller bearing and one in each ball bearing) were used for measuring the temperature of the oil or bearing.

The speeds used in the tests were between 150 and 450 r.p.m., corresponding respectively to about 100 and 300 ft. per minute peripheral speed. Most of the loads used were between 700 and 1800 lb. per bearing, corresponding respectively to about 30 and 80 lb. per sq. in. for the babbitt bearings. All statements of results therefore are subject to the above limitations as to speed and loads, the curves of certain of the figures, however, being extended.

Two lubricants were used in all the tests: Atlantic Red Engine Oil in the babbitt and roller bearings, and No. 2 Keystone Grease in the ball bearings.

RESULTS OF TESTS

Figs. 6, 7 and 8 exhibit the first or immediate results of the tests and show how the power per bearing varied with the temperature at different loads and speeds. The solid lines represent continuous runs and the dotted lines results obtained by dropping either the load or the speed and continuing the run at the previously existing temperature. For all conditions of load and speed the power decreased with increase

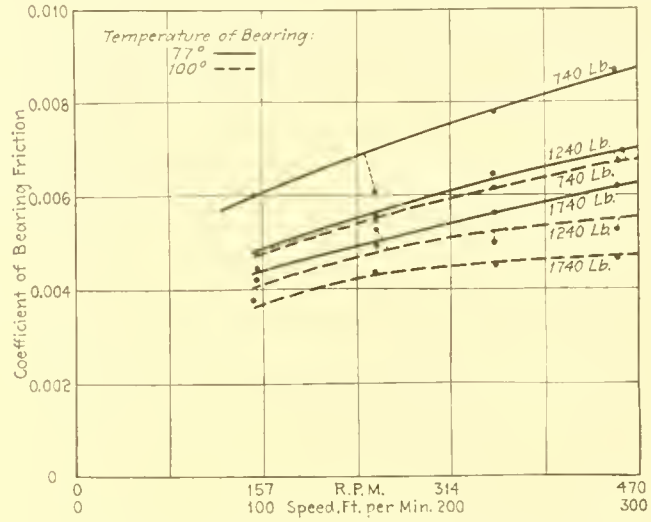

Fig. 16 Roller Bearings. Coefficient of Friction-Speed Curves for Various Loads per Bearing

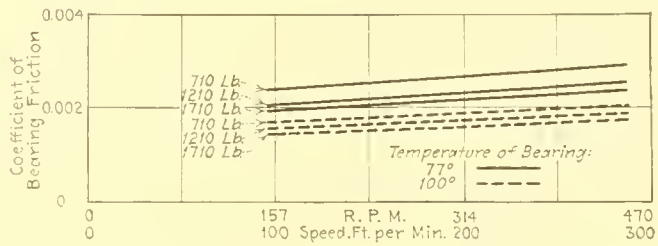

Fig. 17 Ball Bearings. Coefficient of Friction-Speed Curves for Various Loads per Bearing

of temperature, but the rate of decrease at the highest load and speed was not so marked as in the case of the babbitt bearings. At the lower speeds the power did not vary at all with the temperature, practically speaking.

Figs. 9, 10 and 11 show the coefficient of friction-temperature curves for the three kinds of bearings respectively. The coefficient for roller and ball bearings was computed just as for babbitt bearings from the formula

$$f = \frac{\text{(watts per bearing) } 531}{\pi d n \text{ (load per bearing)}}$$

where f is the coefficient, d the diameter of shaft in inches, and n is the number of revolutions per minute, 1 watt being equal to 44.26×12 or 531 in-lb. per min.

Fig. 12 shows power-speed curves for the roller bearings at 77 deg. and 100 deg. temperature; Fig. 13 the

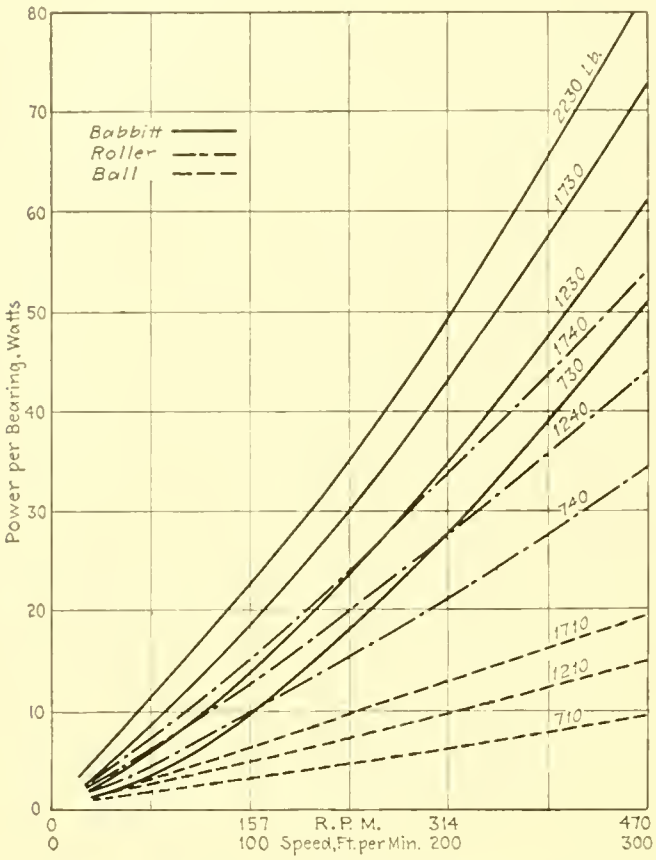

Fig. 18 Comparison of Powers consumed by Friction in the Babbitt, Roller and Ball Bearings, at Loads per Bearing as Indicated and Various Speeds; Temperature of Bearing, 100 Deg. Fahr.

same for babbitt bearings; and Fig. 14 for ball bearings.

TABLE 1 RELATIVE AMOUNTS OF POWER CONSUMED IN FRICTION

Bearings	100 Ft. per Min.		300 Ft. per Min.	
	77 Deg.	100 Deg.	77 Deg.	100 Deg.
Ball	1	1	1	1
Roller	2.2	2.5	2.7	3
Babbitt	3	3.6	4.5	4

Fig. 15 shows the coefficient of friction-speed curves for babbitt bearings; at 77 deg. and 100 deg. temperature; Fig. 16 those for roller bearings; and Fig. 17 for ball bearings.

Figs. 18 and 19 show a comparison of the babbitt, roller and ball bearings for 100 deg. and 77 deg. respectively. Each curve gives the power required per bearing of the kind indicated to run the shaft under the load and speed indicated. Both figures show that the power for the babbitt is higher than for the other bearings except perhaps at low loads and speed, and that the power for rollers is higher than for balls. The excess of power for babbitt over rollers and rollers over balls increases with increase of speed for all loads. Table 1 shows the relative amounts of power consumed in friction by the three kinds of bearings at the speeds and temperatures indicated; the relative numbers are based in each case on the average power for three loads: 710, 1210, and 1710 lb. for balls; 740, 1240, and 1740 for rollers; and 730, 1230, and 1730 for babbitt.

Fig. 20 shows a comparison of rise of temperature for the three kinds of bearings. Curves *A* and *B* were obtained from simultaneous tests on 8 babbitt and 12 roller bearings. The room conditions therefore as well

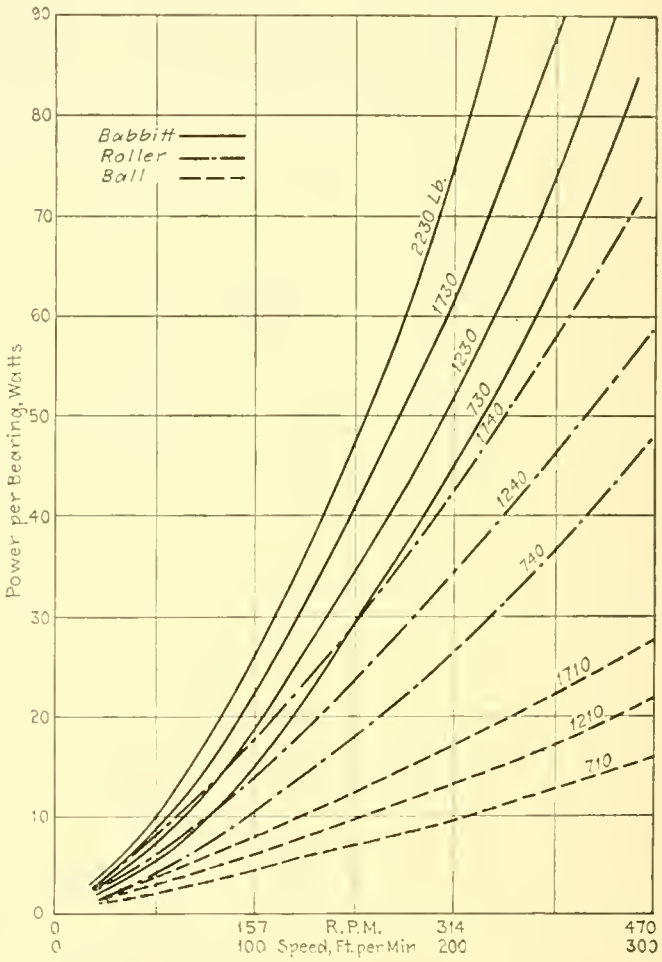

Fig. 19 Comparison of Powers consumed by Friction in the Babbitt, Roller and Ball Bearings, at Loads per Bearing as Indicated and Various Speeds; Temperature of Bearing, 77 Deg. Fahr.

as load and speed were identical for both kinds of bearings. Curves *C* and *D* were obtained from simultaneous tests on 12 roller and 8 ball bearings respectively.

BREAKDOWN TESTS

In order to observe the performance of the bearings under extraordinarily heavy loads, breakdown tests

were run on each type of bearing with only one section of shafting on which were four bearings. This small number of bearings was used because it was impracticable to keep close watch of a larger number of bearings and avoid trouble during the excessively severe conditions. The maximum load was 600 lb. on the scales, or about 5000 lb. per bearing.

The results are shown in Fig. 21. The speed of 200 r.p.m. was chosen because it represents about the average lineshaft speed in practice. These tests began at

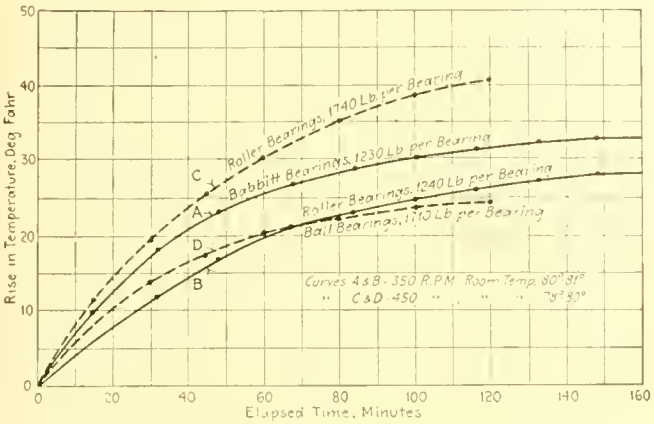

Fig. 20 Rise in Temperature. Different Kinds of Bearings under Practically Identical Conditions

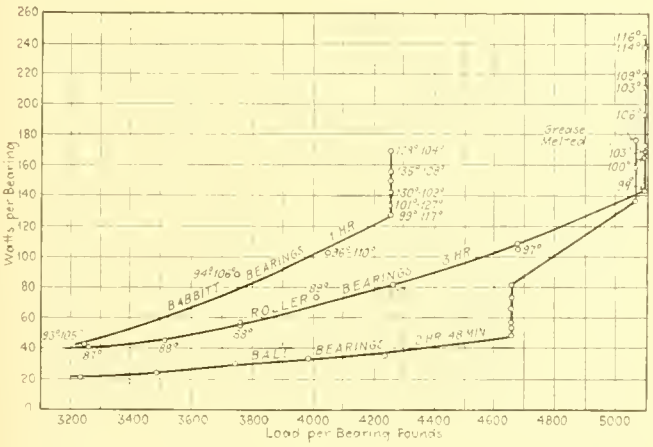

Fig. 21 Breakdown Tests, 200 R.P.M., 128 Ft. per Min.

about 3200 lb. per bearing. Failure occurred at about 4250 lb. per bearing in the case of the babbitt, 4650 lb. in the case of the ball bearings, and about 5100 lb. in the case of the roller bearings. The quality and amount of lubricant used undoubtedly have an important effect upon the load that will cause a given bearing to fail.

The bearings did not in any case "fail" structurally, as the power was cut off soon after distress was manifested, but the failure was simply that of the lubricant. Breaking down of the lubricant results in an immediate increase of the power required to maintain the original speed of rotation of the shaft in the bearings. In each case probably only one of the four bearings used in the breakdown tests showed distress at any one time. In the case of ball bearings, this was evident as distress was manifested by disintegration of the grease which "melted" and ran out of the bearing. This was accompanied by the immediate increase in power requirement, as shown in Fig. 21. The temperatures given (99 deg.-117 deg., etc.) indicate the averages for the four bearings being tested. Similar behavior on the part of the babbitt and the roller bearings indicated that at least one of the four under test was suffering from an approach to "metal-to-metal" contact. The bearings were not injured by these endurance tests, and all were used in subsequent tests at the more usual speeds and pressures.

DISCUSSION

E. H. Ahara (written). This paper is of vital interest to every manufacturer, and will be a decided addition to our engineering literature on this most practical subject. It would be most desirable if our universities could be induced to take up and work out scientifically many of these problems which are constantly confronting the manufacturers of the country who have neither the time, equipment nor staff to handle them except in a very limited way.

In connection with this subject, I have been unable to find anywhere the ratio in heating value between the speed of rotation of a shaft, and pressure per square inch of projected area. Many times a question of the limit of a bearing's ability to carry a load at a high speed of rotation becomes of much more importance than the exact efficiency of the bearing from a power standpoint. John Harper, Mem. Am.Soc.M.E., told me of a case of this kind in which by exceeding the limits of all known authorities on some large babbitted bearings, he was enabled to save nearly a quarter of a million dollars in installation charges.

I notice on the lower pressures, as given in the paper, there is but slight variation in power consumed between the three types of bearings. This would be the case in ordinary practice as the usual shaft transmission bearing of $2\frac{7}{16}$ in. in diameter has less than 500 lb. weight to support.

A babbitted transmission bearing usually has the pressure applied to it in a downward direction or at an angle downward and sidewise (sometimes horizontal) and but rarely upward. They are, therefore, usually designed and oiled for a downward pull, and oil is fed from the top of the liner, as in the babbitted bearings under discussion. It will be noticed that the temperature of the middle bearings of the babbitted type in the university test heated much more rapidly than the end ones. This was undoubtedly caused by the pressure being upward against the cap of the bearings instead of downward on the liner. I have no doubt that in the breakdown test Professor Thomas found the first distress came in a center bearing, and that the average rise in temperature of all the tests were markedly increased by the center bearings where heavy pressures were used.

In some tests made in 1907 by the writer at the plant of the Dodge Manufacturing Company, Mishawaka, Ind., the apparatus was arranged so that the pressure was downward on the test bearing, it being placed between two bearings which took the upward pressure and thus having but half

the load of the test bearing. The test was undertaken to determine the limit of power and speed at which these same babbitted bearings as spoken of in the paper under discussion could be run before the film of oil would no longer stay between the babbitt and the shaft. After much preliminary work a speed of 2200 r.p.m. was settled on, giving a peripheral shaft travel of 1404 ft. per min., and the pressure was gradually increased until the practical limit of the oil was reached; the temperature was measured as in method No. 4 of the paper. None of the bearings were run to destruction; the test at 2200 r.p.m. and a definite pressure being continued until there was no further rise in temperature, when a higher pressure was taken. Different grades of babbitt were used to line the bearings, the oil in all cases being Atlantic red.

Pure lead was tested up to 100 lb. per sq. in. of projected area with a temperature of 292 deg. fahr.; pure tin to 124 lb. with a temperature of 276 deg. fahr.; genuine babbitt with a composition of copper four parts, tin 89 parts, antimony seven parts, reached a pressure of 124 lb. with a temperature of 282 deg. fahr.; and a composition of copper two parts, tin 40 parts, antimony 14 parts and lead 44 parts, reached 144 lb. with a temperature of 290 deg. fahr. A composition of tin five parts, antimony 17 parts and lead 78 parts, reached 83 lb. with a temperature of 298 deg. fahr., and a composition of antimony 15 parts and lead 85 parts reached only 62 lb. with a temperature of 314 deg. fahr. At low pressure no appreciable difference was noticed in the heating values, but in the high pressures the tin-based babbitts with small copper contents were found much superior. In view of these tests I think it would be wise for Professor Thomas to have the babbitt metal of the babbitt bearings analyzed and referred to in the paper.

William Kent regarded the paper as a most valuable contribution to the literature on friction, but would like to see it supplemented with results so illustrated that they would be more immediately available to engineers in designing. For example, referring to Table 1, the relative amounts of power consumed in friction, Mr. Kent would like to have seen that table extended to show what relation the amount of power consumed in friction was to the power transmitted. What designers would like to know are the limitations of load and speed for bearings of different kinds, such as ball bearings, roller bearings, and babbitt bearings, with different kinds of lubricants; in other words, the results of this investigation should be put into convenient form for designers.

Selby Haar, referring to the coefficient of friction as it changed with time of operation, asked whether Professor Thomas had any figures as to the coefficient of friction at the actual moment of starting. That was frequently quite an important thing to know in determining the torque of motors or other apparatus which drives a lineshaft and machinery connected to the shaft. He believed that the ratio of initial to final coefficient of friction was frequently much larger than was given by Professor Thomas.

The Author. Replying to Mr. Kent's question, the curves in Figs. 9 to 19 give the relative and absolute amounts of power required by the various bearings, over the whole range of loads and speeds covered in the tests, and also coefficients of friction under all conditions obtained in the tests. Table 1 is not intended to give more than a few figures, taken from the curve, so as to present a general idea of the relative power consumption of the three types of bearing.

Mr. Haar's question as to change of coefficient of friction with time after starting, and its value at starting, is answered, at least in part, by the curves in Figs. 22 to 25 inclusive (shown only in the complete paper).

Regarding Mr. Ahara's question, as to the loading of the two center bearings on the cap instead of on the bottom of the bearing, the design of the babbitt bearings, with respect to lubrication, made it necessary to apply the load in the manner described. On each section of shaft, two bearings were thus loaded on the bottom and two on the cap. The extent of surface of babbitt was the same in the two cases, and the possible unequal distribution of the lubricant would seem to be the principal disadvantage involved. In the breakdown tests the two center bearings did heat more extensively than did the end bearings, and very probably for the reason mentioned by Mr. Ahara, and referred to in the paper. In the breakdown tests the bearings were loaded probably to six times the normal working load for such bearings.

There is this to be said, that in practice lineshafts are likely to be loaded from various angles, and the conditions obtaining during the tests, as to direction of pressure, might be duplicated. The writers recognized, however, that from the standpoint of effective lubrication, especially during heavy loads, it would be preferable to carry all loads on the bottoms of the babbitt bearings. All three types of bearing were loaded in the same manner as was the case with babbitt bearings. The regularity of the curves obtained in the tests, and the results of a series of temperature investigations, in which the load per bearing was about 2500 lb., indicate that the lubrication of the bearings was quite satisfactory up to the extreme breakdown loads of from 4000 to 5000 lb. per bearing, represented in Fig. 21. It will be noticed that the unit bearing pressures employed during the regular tests described were not unusually high, being between limits of about 30 and 100 lb. per sq. in. of projected area, for the babbitt bearings. During the breakdown tests the loads at which the lubricant broke down, in the various types of bearing, varied from about 180 to 230 lb. per sq. in., referred to the area of babbitted bearings. The temperatures attained are shown approximately in Fig. 27.

Analysis of the babbitt had not been made up to the time of writing this paper, but will be made and reported at a later date. It is planned to extend the work so as to include other features of performance, including the question of ultimate time of endurance under the working conditions found in practice.

PITOT TUBES FOR GAS MEASUREMENT

By W. C. Rowse, New York

Member of the Society

ABSTRACT OF PAPER[1]

A series of experiments has been made by the author at the laboratories of the University of Wisconsin to obtain information concerning the reliability of the pitot tube as a means of measuring gases and to determine the accuracy of various forms of the instrument which are in common use. All tubes were compared with a Thomas electric gas meter which was taken as a standard of measurement. Since any variation in results would be due to a wrong method of obtaining the static pressure, simultaneous readings were taken of velocity heads as shown by the pitot tube using the pitot static pressure and by the pitot dynamic tube and a piezometer. The pressure as obtained by the piezometer would not be affected by the form of tube used.

The apparatus used in the experiments is shown diagrammatically in Fig. 1. A Sirocco fan driven by a direct-current shunt-wound motor forces air through the Thomas meter into a galvanized iron pipe 12 in. in diameter in which the pitot tube is inserted. Variable resistances were placed in series with both the field and the armature of the motor, making possible a wide variation in speed. Screens were inserted at the points shown in order to break up eddies and whirls and to have the air flow as nearly parallel as possible at the point where the pitot readings were taken.

The experimenter was stationed directly under the pitot tube and all readings were taken at this point. A mercury barometer, hung on the adjacent wall, gave the atmospheric pressure, and a manometer inclined at a 10 to 1 slope made it possible to determine accurately the static pressure in the pipe above atmosphere. The dry-bulb thermometer indicated the temperature of the air flowing in the pipe and together with the wet-bulb thermometer gave readings from which the humidity could be determined.

The pitot tube is a well-known measuring instrument and needs only a brief description. It consists essentially of two parts: a dynamic tube pointing upstream which converts the sum of the pressure energy and the velocity energy into a head which may be measured; and a means of determining the pressure head (or static pressure) alone. The difference between the dynamic head and the static pressure head is the velocity head h in the fundamental formula for the flow of fluids

$$v = \sqrt{2gh}$$

It has been satisfactorily proved and accepted that the dynamic tube of a pitot tube gives the correct pressure if the tube points parallel to the current. But it is a very difficult matter to obtain the correct static pressure on account of secondary velocity effects. Therefore the study of the accuracy of the pitot tube resolves itself into a study of the correct method of obtaining the static pressure at the given cross-section where the tube is inserted.

Each pitot tube tested had as a part of the tube a means of determining the static pressure, and readings of the velocity head were obtained by using this pitot tube static pressure. Simultaneous readings of the velocity head were obtained by using a piezometer ring for the static pressure together with the dynamic tube of the pitot tube under test. This is further illustrated by reference to Fig. 1. Manometer B gives the

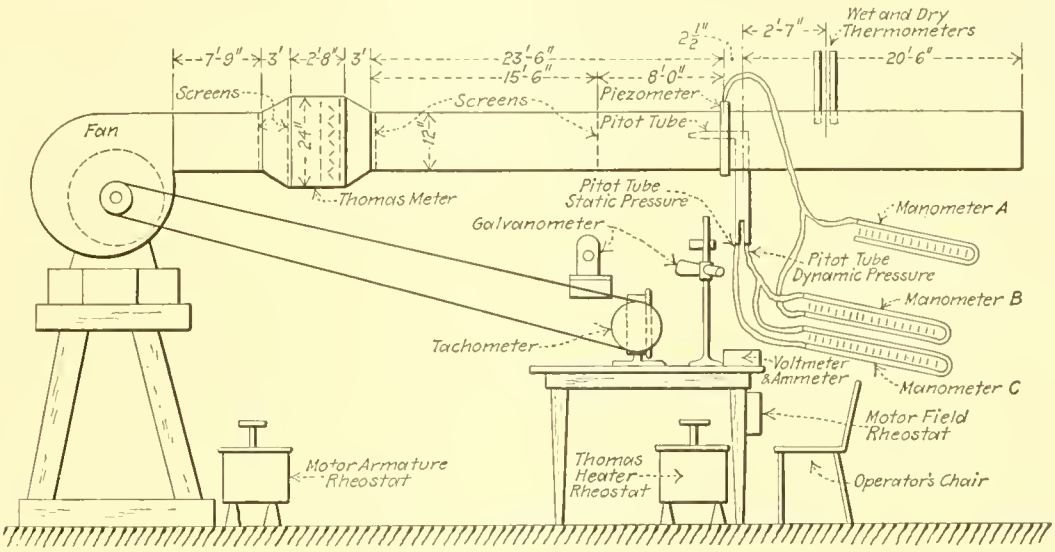

Fig. 1 Sketch of Apparatus

[1] Published in complete form in the September 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the annual meeting, December 1913. Pamphlet copies may be obtained: price, 20 cents to members and 35 cents to non-members.

velocity head by using the piezometer static pressure, and manometer C gives the velocity head by using the pitot tube static pressure. In both cases the same additional means of *comparison* independent of the Thomas meter.

The piezometer is shown in Fig. 1 and Fig. 3, and is

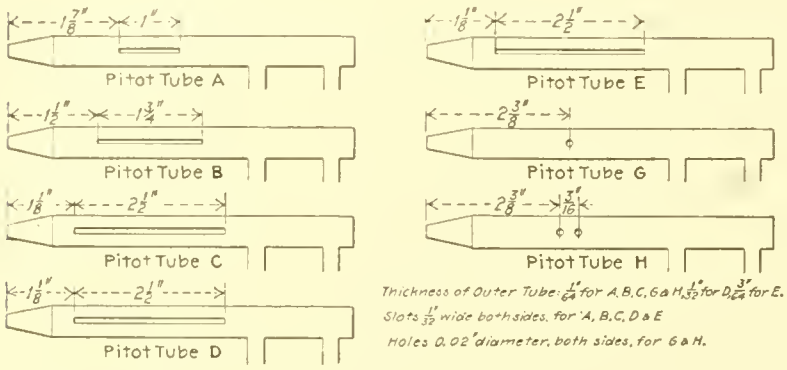

Fig. 2 Sketches of Pitot Tubes A to H showing Dimensions of Static Openings

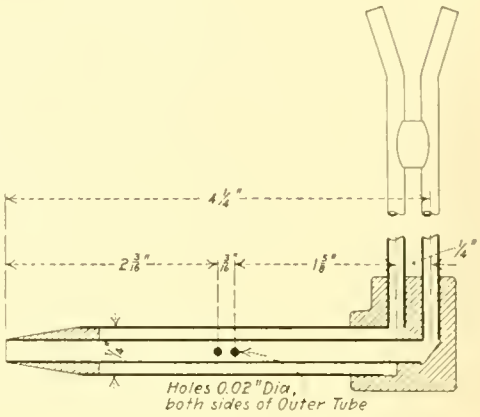

Fig. 5 Pitot Tube Y

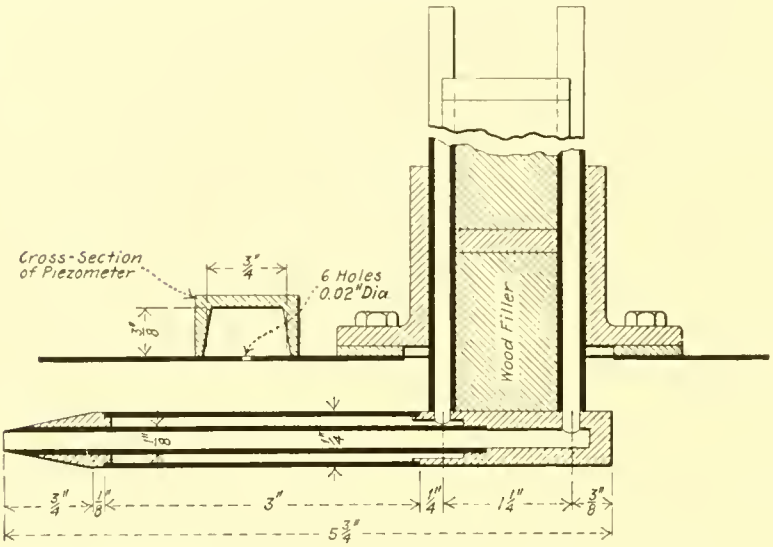

Fig. 3 Dimensioned Sketch of Pitot Tubes A to H

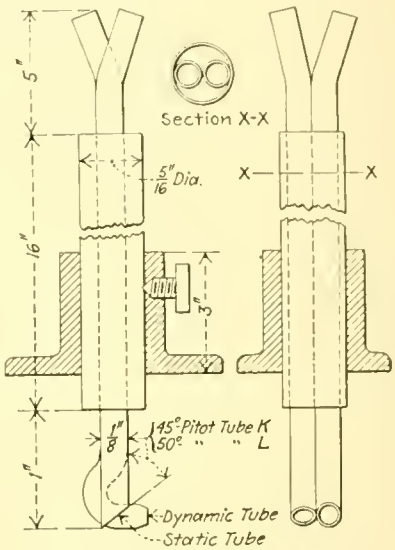

Fig. 6 Tubes K and L

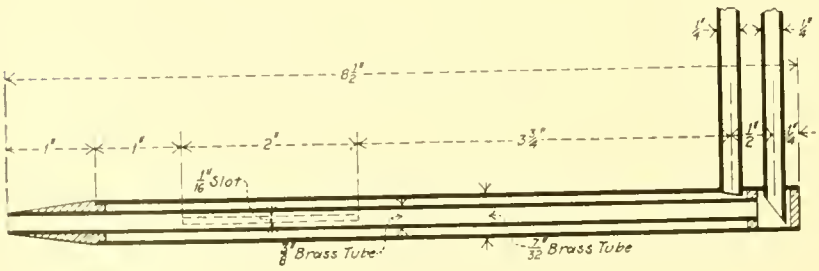

Fig. 4 Dimensioned Sketch of Pitot Tube X

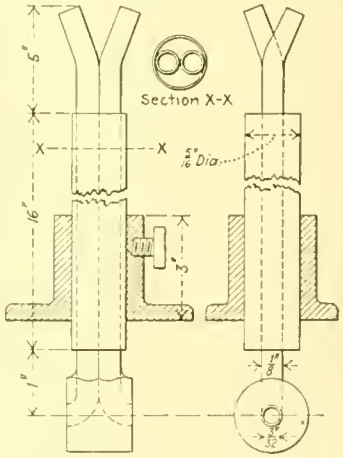

Fig. 7 German Stauscheibe

dynamic tube pressure is used. This piezometer, even if it were possible to be in error, would always indicate the same pressure under the same conditions irrespective of the tube under test and thus it afforded an simply an absolutely air-tight annular space about the pipe, connected with the interior of the pipe by six small holes 0.04 in. in diameter.

A large number of readings was taken across two

diameters of the pipe. The total area of the pipe was divided into five concentric annular areas and four readings of the velocity head were obtained in each test at the center of each annular area, thus giving 20 readings from which the mean velocity head could be calculated. Since the velocity varies as the square root of the velocity head it was necessary to average the square roots of each of the 20 readings, and the square of this average represented the mean velocity head.

As to the limits of accuracy, the accuracy of the measuring instruments used is much greater than can be expected from the pitot tube as a means of measuring gases, due to the uncontrollable variation in the air flow. The considerations which may prevent even an absolutely correct pitot tube from giving true results are as follows:

a The air flows through the pipe in a wave or spiral motion and at no time is the velocity uniformly distributed across the pipe, being greater in one quarter than in the other three quarters; the quarter of highest velocities may or may not be on the diameters where pitot tube readings are being taken.

b The velocities on the diameters where pitot tube readings are being taken may be constantly varying during the period of time necessary to obtain the readings; thus the average of all readings may be slightly too large or too small.

c The air flow can only approach, never reach, the ideal conditions of parallel flow, and the pitot tube is correct, theoretically, only when the tube is exactly parallel to the current of air.

From these considerations, together with the author's experience in this line of work, it is estimated that the results obtained in measuring gases by an absolutely correct pitot tube may vary 1 per cent, more or less, from the correct results. Of course, the average of a large number of tests should be more nearly correct than this, for the plus errors will probably neutralize the minus errors.

From a study of the summary of the tests, the following general results and conclusions may be stated:

a The pitot tube as a means of measuring gases is reliable within approximately 1 per cent when the static pressure is correctly obtained and when all readings are taken with a sufficient degree of refinement; in order to obtain this degree of accuracy the pitot tube should be preceded by a length of pipe 20 to 38 times the pipe diameter in order to make the flow of gas as nearly uniform across the section of the pipe as possible.

b All the methods of obtaining the dynamic head used in these experiments, including the Stauscheibe, give accurate results.

c The most reliable and accurate means of obtaining the static pressure is the piezometer or its equivalent, the results of 138 separate tests using the piezometer static pressure agreeing with the Thomas meter within an average of 0.33 per cent; these results show beyond any doubt that the static pressure is constant across any section of a pipe in which gas is flowing at a uniform rate.

d Of the methods of obtaining the static pressure by the pitot tube itself, the most reliable and accurate is by means of a very small hole in a perfectly smooth surface, as in pitot tube *Y*.

e The long slots for obtaining the static pressure are not reliable and give results which are in error from 3.5 to 10 per cent. The length of the slots or the thickness of the outer tube do not appear to affect the accuracy of the tube.

f The beveled tube for obtaining the static pressure as used in pitot tubes *K* and *L* is not reliable. A very slight change in the angle of bevel produces an appreciable change in the result. In taking a traverse of a pipe the sides of the pipe affect the readings. But the greatest error is produced by the uncertainty as to whether the tube is pointing directly upstream. The effect of allowing the tube to point at an angle of 20 deg. off the direction of flow is to introduce an error of 85 per cent in the velocity head.

g The Stauscheibe gives accurate results using either the static reading from the Stauscheibe and the special formula for it; or by using the piezometer static with the usual formula for the pitot tubes. In the first case the agreement is within 1.4 per cent and in the second within 0.16 per cent.

h It appears that an approximate relation exists between the mean velocity head of a gas flowing through the pipe and the velocity head found by placing the tube at the center of the pipe. For a 12-in. galvanized iron pipe results within 2 per cent may be expected from using the formula

$$v = \sqrt{(2g)\ (0.80)\ h_c}$$

where

v = velocity in ft. per second.

g = 32.2 ft. per second per second.

h_c = velocity head at the center of pipe in feet of gas flowing.

DISCUSSION

D. S. Jacobus asked the author whether or not he had determined what happened at the first ordinary point of critical velocity, and whether he had carried the velocity high enough in his experiments to show whether there was a second critical velocity. Apparently, in the use of some steam flow meters there were some peculiar actions when the velocities got up to a very high figure, and there was indication of the possibility of a second critical point.

W. H. Carrier (written). The paper throws light on a source of possible error in the readings of the pitot tube which has been troubling me for some time. Mr. Rowse shows that the impact pressure is not appreciably changed

by an angular deflection of the pitot tube of as much as 15 deg. in either direction. This means that where there is a swirl or turbulence in the air so that the direction of flow at the point of measurement is not parallel to the air duct, that is, normal to the plane of measurement, that there may be a considerable error introduced, since the pitot tube will indicate the relative velocity of swirl in addition to the effectual velocity of flow parallel to the pitot tube. It is also very difficult to get accurately the rapid drop in velocity occurring near the surface of the air pipe or conduit. For these reasons, it will often be found in practical installations that even with a very careful use of the pitot tube, apparent air quantities will be obtained which are 5 per cent or more higher than the actual.

Of course in a laboratory or shop test, as conducted by Mr. Rowse, where comparatively long straight piping is used and special means are taken to insure substantially parallel flow, as well as uniformity of velocity, the results given by the pitot tube will be exceedingly accurate, as his tests indicate. In practical fan installations, however, it is usually impossible to obtain anywhere near such favorable conditions for accuracy of measurement. In about nine cases

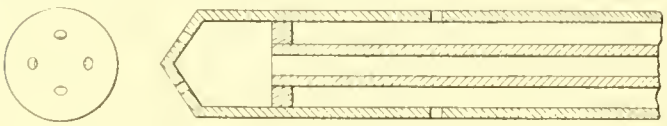

Fig. 8 Special form for Impact End of Tube

out of ten it is necessary to take the measurements either at, or close to, the fan outlet, where there is a great deal of turbulence in flow, as well as a great variation in velocity. In all such cases too great a reliance should not be placed upon the accuracy of the pitot tube.

On account of this inherent source of error in the form of pitot tube advocated by Mr. Rowse, it should be adopted as a standard instrument only until some more reliable and perfect form is devised. Such an improved form of pitot tube should give an impact or differential reading which would vary properly with the angle of deflection of the pitot tube with respect to the direction of velocity; that is, for the accurate integration of effectual velocity in turbulent flow, the effectual velocity pressure should correspond substantially to the following formula at various angles of velocity direction

$$p_e = p', \cos^2 a$$

where P_e = the effectual velocity pressure indicated by the differential gage and pitot tube

P' = the actual velocity of the air at some angle to the tube

a = the angle of deflection of the pitot tube with respect to the actual direction of the air velocity

It would seem quite possible that with some experimentation such a reliable form of pitot tube could be produced. This could be accomplished in either one of two possible ways:

a By constructing the impact member so that it will be sensitive to the change of angle in any direction, as shown in Fig. 8.

b By constructing the static member so that it will increase the static pressure with any change of angle sufficient to compensate for the error in the impact member.

Karl Nibecker asked the author if he had found a critical velocity at which the pitot tube ceased to be accurate. Recently in some work with turbo blowers where the machine was working at high pressure, the only means of discharge for the air was a comparatively small pipe. The velocity in this pipe, where it was necessary to measure the air, exceeded, by a considerable amount, any velocity that had been attained before within the speaker's experience and which had been measured with the pitot tube. It occurred to him, that very probably there was a point where the velocity was such that the pitot tube could no longer be considered an accurate means of measurement, although it has been found to be accurate for low velocities. In the case in question, the pressure was also much higher than ordinarily obtained in pipes supplied by simple fans. The pressure in the line to be measured was about 30 lb. per sq. in. and the velocity was in the neighborhood of from 1000 to 1200 ft. per sec.

C. C. Thomas (written). Referring to *c* under Limits of Accuracy, I understand that this refers to the static pressure only, and that the curves in Fig. 16 (of the complete paper) indicate that the static pressure is constant over the cross-section of the pipe. If the static pressure is measured by use of the piezometer ring, it appears that the dynamic tube may point at quite an angle with the direction of flow without seriously affecting the reading of velocity head. In this connection, it would seem that *f* under Results, should have the words "due to incorrect static readings" added to the last sentence in the paragraph.

Leo Loeb (written). The paper has served to clear up many of the problems connected with the measurement of gases with pitot tubes, but the conclusions reached in regard to the reliability of certain forms of pitot tubes should not seriously question previous tests involving measurements of the flow of air when properly using these forms of tubes.

In the early comparative tests between the Thomas and venturi meters and the Taylor pitot tube, C. C. Thomas reports in a paper[1] that for air velocities between 1500 and 3000 ft. per min., "the pitot, venturi and electric meters will all give accurate and reliable results when properly used under favorable conditions and when observations are taken with a sufficient degree of refinement in method. . . . The close agreement of the results obtained in the measurement of a common quantity by these three fundamental and independent methods of measurements, with independent observations taken for each, forms, from a scientific standpoint, a very interesting proof of the correctness of the several theories involved." The pitot tube used by Professor Thomas is almost the same as Mr. Rowse's type *X*, the slots being respectively 3/64 in. and 1/16 in. wide and in both cases 2 in. long. The general arrangement for test was the same and the fans differed in capacity by the ratio 4:3. It appears strange therefore, that while Mr. Rowse calls attention to an average of 9.87 per cent variation between the electric meter and type *X* tube, he does not attempt to reconcile such results with reports from the same laboratory of an average variation of 0.38 per cent between the two meters.

[1] The Measurements of Gases, Journal of the Franklin Institute, November 1911, p. 411.

The Taylor tube with slots 1/16 in. wide and 2½ in. long was used in the measurement of air delivered through a 12½-in. duct to an air heater tested at the United States Naval Engineering Experiment Station in May 1912. Except for the radiation losses, which were determined by a separate test, the apparatus also formed an air meter of the heater type in which steam was the heating medium. While the object of the test was to investigate the heat transfer of the apparatus, the results furnish a sufficient check on the accuracy of the air measurements to be presented in this connection. All tests were of 30 minutes duration with observations every 5 minutes.

1	Test number	I	II	III	IV
2	Barometer, in. of mercury	30 42	30.38	30.49	30 42
3	Static air pressure, in. of water	0.64	1.91	2 62	3 91
4	Absolute air pressure, lb. per sq. in.	15 05	15.07	15.14	15 16
5	Room temperature, deg. fahr.	71.3	64.3	67.0	58 2
6	Air entering heater, deg. fahr.	37 9	35 9	38.2	39 1
7	Air eaving heater, deg. fahr.	144 8	130.0	128.9	123 8
8	Relaltive humidity entering air	79.9	74 0	66.1	65 1
9	Weight of moist air, lb. per cu. ft.	0.08098	0 08148	0.08151	0 08142
10	Mean specific heat of air, B.t.u., per lb.	0 2477	0.2457	0 2454	0 2452
11	Steam pressure, lb. gage	96.5	96 6	96.5	96 1
12	Steam quality, per cent	0.9879	0 9918	0.9957	1 9 (superheat)
13	Average air velocity by pitot tube, ft. per min	956	1677	1992	2420
14	Lb. of air per min	66 00	116 43	138.00	168.94
15	Steam condensed per min., lb.	2 050	3 092	3.517	4.058
16	Heat yielded by steam, B.t.u., per min	1792	2710	3091	3591
17	Heat absorbed by air, B.t.u., per min	1748	2691	3072	3508
18	Heater efficiency	0.976	0 993	0.994	0 977
19	Radiation and losses, B.t.u., per min. computed from radiation test	7	7	6	9
20	Pitot tube coefficient	0.980	0.996	0 996	0.980

The above are only four of a series of 20 tests, all of which verified the results that the tube coefficient varied from 0.98 to 1.00. The average velocity was obtained by a traverse on two diameters using 22 points for observations on each diameter.

A form of inclined manometer which has been used with considerable success is shown in Fig. 9. It consists of a U-tube secured in such a way as to permit the two legs to remain always in the same vertical plane at the same time allowing them to take any desired inclination. The scale is a carefully selected sheet of cross-section paper. This manometer uses as a fluid a mineral oil of density 0.825 and forms its own leveling device, since there is visible both a distinct vertical and horizontal meniscus. The horizontal meniscus of the two tubes is leveled to the same horizontal line on the cross-section paper by swivelling the backing board, and readings are taken on the horizontal scale. The net reading multiplied by the inclination and the oil density is the true head. The scale multipliers are 0.2, 0.5 and 1.0, which with a 12-in. tube cover the entire range of pressures encountered with forced draft blowers.

There seems to be a difference of nearly 2 per cent on the average between results with tubes *H* and *Y* although the dimensioned sketches show almost identical proportions, differing only slightly in overall length and lead connections at shank.

There are cases where the Thomas meter could not be used on account of its introducing resistances against which the fan would not operate in practice. An alternate method of measuring the discharge would be a simple outlet nozzle traversed with an impact tube at sufficient points to give an average velocity. It is therefore to be regretted that Mr. Rowse did not combine with his experiments a traverse of the pipe outlet to determine how completely the static pressure was converted into velocity head.

F. R. Still (written). The writer, as a designer and builder of fans and blowers and deeply interested in the subject of air measurement for nearly 30 years, has developed a number of instruments for the purpose, but finally settled on the one designated as pitot tube *Y* in Mr. Rowse's paper. This tube has been calibrated in many different ways, such as whirling it on a shaft and correcting for the

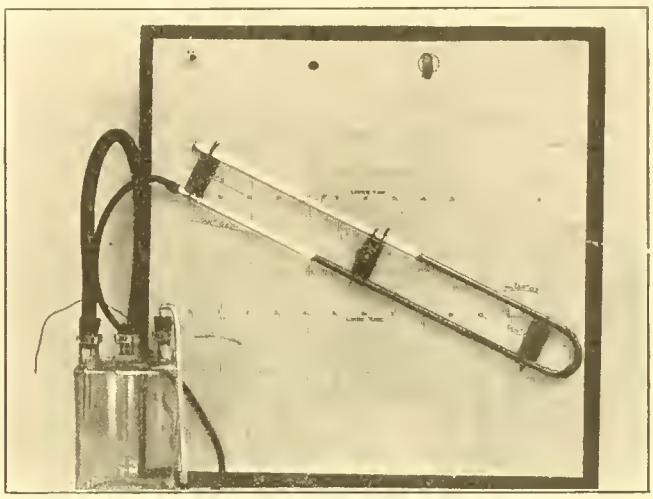

Fig. 9 Inclined Manometer

centrifugal force, by measuring the flow through a tube leading out from a gas holder, and in a pipe in which the flow was simultaneously measured by the Thomas meter. These various comparative tests showed this tube to be less than 1 per cent below the actual velocity. The larger the pipe, the less will be the variation from the actual velocity, as the friction along the walls of the pipe is proportionately less in a large pipe than in a small one.

The particular advantage of the pitot tube is that it is more accurate than any other portable instrument available; in fact, there is no other form of device, either portable or stationary, for measuring accurately large or small volumes at high or low velocities in large or small pipes, which at the same time determines the static pressure or resistance to the flow. The latter is quite as essential to the determination of the work performed as is the determination of the velocity or volume.

The accuracy of the results obtained is largely a measure of the care exercised in the preparation for, and the taking of the readings. The author is correct when he says that the further the readings are taken from the fan the longer will be the spiral or wave of the air as it passes through the pipe. When it is necessary to take readings close to the fan, the cross-section of the pipe should be divided into more and smaller zones so as to get a better average.

The author states further that since the velocity varies as the square root of the velocity head, it was necessary to average the square roots of *each of the* 20 *readings,* and

the *square of this average* represented the mean velocity head. This is unnecessary if the cross-section of the pipe is divided into numerous zones of *equal area;* doing this at first simplifies very much the later computations. For instance, if each zone is of equal area and reasonably small, the average result must be the average velocity of all these areas. But if the pipe is divided into *equal divisions* but of *unequal areas,* then the average of the pressure readings will not give the correct average velocity.

It is indeed very gratifying to note the attention air measurement is receiving of late and the efforts being made to arrive at some standard method of procedure, as well as the design of some simple, standard, portable instrument for such purpose. The thoroughness of Mr. Rowse's investigations and comparisons should establish definitely the best form of pitot tube for accurate results, and not only settle the ever recurring question as to the accuracy of any type, but also settle once and for all the relative accuracy of the different types, which latter has never heretofore been thoroughly established in the minds of but few engineers.

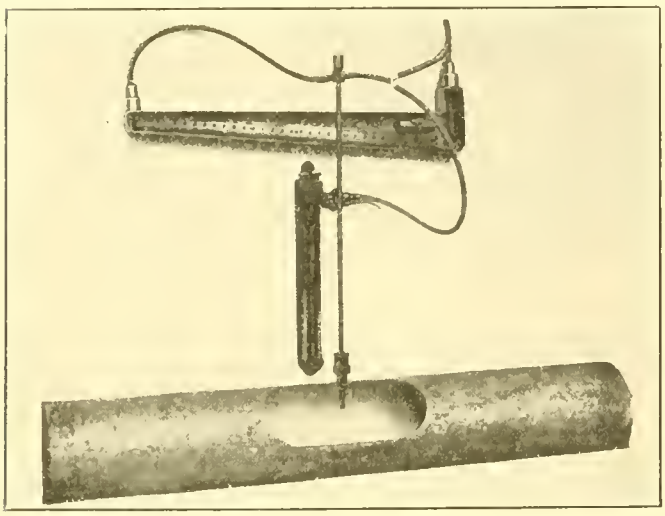

Fig. 10 Tube applied to Circular Conduit

G. F. Gebhardt (written). The pitot tube with beveled-end static opening originated, the writer believes, in the laboratories of the Armour Institute of Technology. At least no information pertaining to this style of tube was available when the first experiments were made in the year 1904. The sole object of beveling the end of the static tube is to permit of a compact, portable construction which may be readily introduced into a conduit through a single small opening. The application of a commercial design of this tube to a circular conduit is shown in Fig. 10.

Mr. Rowse's conclusions that the beveled-end static opening is not reliable, is true only where extreme accuracy is desired. According to his own experiments the *average* departure of the beveled-end pitot tube from that of the pitot tube with piezometer static, which he considers reliable, is less than 0.7 per cent for full gate and a trifle above 0.6 per cent for half gate opening (Table 14 of complete paper). The *maximum* departure is 1.6 per cent for full gate and 1.3 per cent for half gate opening. The average departure from the Thomas meter readings is 1.8 per cent for full gate and 1 per cent for half gate opening. Tests conducted by Mr. Kneeland[1] with tubes furnished by the writer gave results agreeing within 1.5 per cent of volumetric determinations for all velocities up to 8000 ft. per min. Numerous experiments made in the laboratories of the Armour Institute of Technology on 100 or more tubes with beveled-end static openings gave results agreeing within 2 per cent of holder displacements. For most practical considerations this error is well within the accuracy of other factors involved in determining the flow of gases.

Mr. Rowse is to be congratulated upon the thoroughness of his investigations and for having grouped in a convenient form the relative defects of the various types of pitot tubes commonly employed in measuring the flow of gas in closed conduits.

C. P. Crissey (written). Engineers interested in the measurement of air and other gases will find much of value in the Rules for Testing Blowers and Compressors approved by the Verein deutscher Ingenieure in 1912, and published in a pamphlet entitled Regeln für Leistungsversuche an Ventilatoren und Kompressoren. Among other

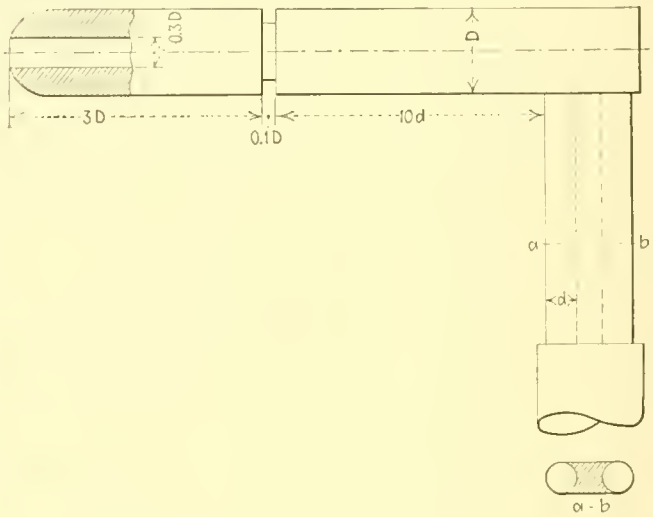

Fig. 11 Prandtl's Tube with Spherical End

things, these rules recommend a tube known as Prandtl's pitot tube. From Fig. 11 it will be seen that this form of tube has a hemispherical head, and a slot extending around the entire periphery. It is stated that a deviation of 15 deg. from the direction of flow has no effect upon the velocity readings, but the static pressure reading is lowered if the deviation is more than a few degrees. Possibly experiments with such a tube will show it has no advantage over some of the tubes so carefully tested and reported upon in this paper, but before a standard tube is adopted it would seem well worth while to investigate the merits of Prandtl's pitot tube.

A. G. Christie (written). Mr. Rowse found that several tubes which had heretofore been regarded as suitable for this work, gave results considerably in error. The care that he took to break up wave action in his test pipe and his comments on this phenomena would indicate that considerable discretion must be exercised in the use of pitot

[1] Trans., Am. Soc. M. E., vol. 33, p. 1155.

tubes for the measurement of air or gases discharged by fans or compressors.

In Europe the method generally used for measuring fan or compressor capacity is to discharge through orifices with well rounded mouths. However, there exists a considerable difference of opinion among English and Continental engineers as to the forms of these orifices, their finish and the discharge factors to be applied to them, in spite of the fact that a committee of the Verein deutscher Ingenieure have published a set of rules for power tests on fans and compressors.

In America many different methods are employed in testing fans and compressors, and up to the present time there have been no recognized standard methods or standard test apparatus. Engineers in both Europe and America employ several different expressions for defining efficiency with as many ways of calculating them. Hence, reports of compressor tests are of little use unless the method of calculating them is also available for inspection.

There is an urgent need of a clear, comprehensive statement of means, methods and apparatus to be used in such tests together with an elaborated definition of the expressions of efficiency.

THE AUTHOR. Dr. Jacobus and Mr. Nibecker have asked questions regarding a critical velocity at which the pitot tube ceases to give accurate readings. No such critical velocity was observed in these tests, the highest velocity reached being about 4500 ft. per min., which was the limit of the apparatus. Tests are now being conducted at the University of Wisconsin with higher velocities and smaller pipes which may provide further information on the subject.

Mr. Carrier's remarks regarding the practical difficulties in accurately measuring fan discharges are very interesting and illustrate the care which must be observed in order to obtain even approximately correct results. Of course, the experiments reported in the paper were conducted under laboratory conditions in order to compare the accuracy of various forms of tubes. The accurate measurement of gases under practical conditions has its own peculiar difficulties, but it is at least something to know that the pitot tube used would give correct results if the conditions were ideal. It is then the engineer's problem to take his readings at such a point and in such a manner as he thinks will give best results.

Mr. Loeb has noted that there is a variation of almost 2 per cent between results obtained by tubes H and Y, although the tubes are almost identical, which probably represents the possible error of the pitot tube as a means of measuring gases. It would be well to state here that several other tubes of this type have been tested at various times at the University of Wisconsin, using this same apparatus, and in every case the agreement between the pitot tubes and the Thomas meter has been so close as to leave in the author's mind no doubt as to the accuracy of this type of tube.

A close study of the tests reported by Prof. C. C. Thomas in the Journal of Franklin Institute, to which Mr. Loeb has referred, will show that the pitot tube used in those tests had small holes in addition to slots; that insufficient precautions were taken to produce parallel flow at the pitot tube; and, most important, that readings were taken on *one radius* only. The readings thus obtained gave the average velocity for only one-quarter of the pipe cross-section, which in this case gave results agreeing closely with the Thomas meter. If readings had been taken across *two diameters* the agreement might not have been so close. Of course it might be possible to make a pitot tube with slots for obtaining the static pressure which would give correct results, although one could not be sure of this fact unless the tube were calibrated.

In answer to Mr. Still's statement that it is unnecessary to average the *square roots* of the observed velocity heads, when the readings are taken at the centers of equal areas, the following mathematical proof is offered:

Let the cross section of the pipe be divided into five equal annular areas, A_1, A_2, A_3, A_4 and A_5.

Let the velocity heads at the centers of these annular areas be h_1, h_2, h_3, h_4 and h_5.

Let the velocities at the centers of these annular areas be V_1, V_2, V_3, V_4 and V_5.

$V_1 = K\sqrt{h_1}$; $V_2 = K\sqrt{h_2}$; etc.

$$\text{total discharge} = A_1V_1 + A_2V_2 + A_3V_3 + A_4V_4 + A_5V_5$$

or

$$\text{total discharge} = 5A_1 \left\{\frac{V_1 + V_2 + V_3 + V_4 + V_5}{5}\right\}$$

or

$$\text{total discharge} = (\text{total area})\ (K)$$

$$(\text{total area})\ (K) \left\{\frac{\sqrt{h_1} + \sqrt{h_2} + \sqrt{h_3} + \sqrt{h_4} + \sqrt{h_5}}{5}\right\}$$

A large number of trials from actual tests showed that averaging the velocity heads themselves instead of the square roots gave results from ½ per cent to 1½ per cent too high, the error increasing with the variation between the highest and lowest readings observed.

Professor Gebhardt's remarks concerning the pitot tube having a beveled tube to obtain the static pressure should certainly be taken into consideration in determining the merits of that type of tube.

Professor Thomas has pointed out a result of these tests which the author neglected to emphasize, namely, that for all engineering purposes, the static pressure is constant across the cross-section of the pipe.

Several suggestions have been made as to further experiments with pitot tubes for the measurement of gases which may be summarized as follows:

a Tests with low pressures and high velocities. (Such tests are now being conducted at the University of Wisconsin.)

b Tests at high pressures and both high and low velocities.

c Tests to determine the existence of critical velocities.

d Traverses at pipe opening.

e Tests using various sizes and shapes of pipes.

f Experiments to determine a practical substitute for a piezometer, as the piezometer used by the author would be difficult to apply in many cases.

g Experiments using other forms of the pitot tube, such as the Prandtl tube mentioned by Mr. Crissey.

In conclusion the author wishes to second heartily Professor Christie's motion that, just as soon as engineers feel that there is sufficient data at hand, a standard pitot tube for fan tests should be specified and standard procedure and rules for fan tests adopted by the Society.

MACHINE SHOP SESSION

PAPERS CONTRIBUTED AT THE ANNUAL MEETING BY THE SUB-COMMITTEE ON MACHINE SHOP PRACTICE

GEARS FOR MACHINE-TOOL DRIVES

By John Parker, Providence, R. I.

Member of the Society

ABSTRACT OF PAPER[1]

There are well established gear conditions common to the majority of machine tools which, if noted, may prove somewhat of a guide in selecting the proper material for gears. These may be classified as follows:

a Gears always in mesh; material to be cast iron, machinery steel or machinery steel case-hardened, according to speeds and duty.

b Gears in sets that are removable and interchangeable, such as change gears for thread cutting, indexing, feed or speed changes, etc.; material, cast iron.

c Gears in sets that are non-removable and partially interchangeable, used as quick-change feed gears with changes made when in motion; or as quick-change speed gears with changes made when at rest but subjected to high speeds and heavy duty. Material, machinery steel case-hardened.

d Gears in use part of the time only and engaged or disengaged when the machine is stopped. Material, hard, close-grained cast iron.

The Objections to Cast Iron. The objections to cast iron for gears cover both wear and breakage. If the speed is excessive, say above 500 ft. per minute, they are likely to wear quite rapidly; and on slow speeds and heavy pressure breakage will occur, unless they can be made of adequate size, as in the case of back gears so located in the machine that it is possible to employ large diameters, coarse pitches, and wide faces.

The Safe Tooth Pressure for Cast-Iron Gears. The question of tooth pressures in cast-iron gears is somewhat problematical. The Brown & Sharpe Manufacturing Company have in successful operation a gear in the spindle drive of their largest milling machine made from a hard, close-grained cast iron having a tensile strength of 23,000 lb. per sq. in., which when running at the slowest speed sustains a pressure on the teeth of 8250 lb. It is calculated that two teeth are always in contact, which gives 4125 lb. pressure per tooth. The area in cross-section of each tooth is 1¼ sq. in., equaling 3300 lb. per sq. in.; when the gear runs at the fastest speed the pressure is about 1000 lb. per sq. in. It is not known whether the pressure could be increased to any considerable extent, but it has been overloaded to at least 30 per cent without injuring it; this was when testing out the machine and the overload was of short duration. It might be said that this gear is not subjected to any sudden shock; if it were, the allowable tooth pressure would be considerably less.

The Grades of Steel that have given Best Results and how They have been treated. For gears that are of small proportions and yet are subjected to heavy duty, it has been found that in cases where the more common steels have failed, excellent results have been obtained from using a 5 per cent nickel steel. This steel casehardens with a very hard surface and still has a strong and tough core, making it an ideal steel to use where the pressure is heavy or the gear is subjected to shock. Experience shows that drop forgings are more uniform in texture than bar stock. This grade of steel is given an oil treatment and is also annealed before machining; the oil treatment is as follows: heat to 1550 deg. fahr. and quench in oil. To anneal, reheat to 1350 deg. fahr. and cool very slowly. It is then ready to machine.

After machining, it is carbonized as follows: pack in any good carbonizing material and cover very carefully to exclude air, place in furnace and heat to 1700 deg. fahr., and hold long enough to get the desired depth of casing. Care should be taken to have it heated entirely through. Ordinarily three to four hours will suffice for this process. Then take out of furnace and cool off in the boxes; remove from the boxes and place in furnace or bath; reheat to 1550 deg. fahr. and quench in oil. Again reheat to about 1380 deg. fahr. and quench in oil or water according to the size and shape of gear. If the gear is of generous dimensions and free from sharp corners, water is preferably used. Small slender gears are quenched in oil, on account of the liability of cracking if water is used. For ordinary gears the scleroscope test should show 80 to 85 points of hardness. If the gears are used as clash gears they should be drawn to 475 deg. fahr., or about 70 to 75 points of hardness, by scleroscope test, to avoid chipping.

Degree of Hardness Advisable for Steel Gears before Machining Them. The various kinds of steels used for gears are of such a nature that they do not call for treating before machining, but where extra toughness in shafts is required to withstand torsion and bending

[1] Published in complete form in the November 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the Annual Meeting, December 1913. Pamphlet copies may be obtained; price, 5 cents to members and 10 cents to non-members.

strains, 3½ per cent nickel steel is very satisfactory. This grade of steel is rough machined, then heat treated, as follows: place in open furnace or bath, heat to 1500 deg. fahr., and quench in oil. It is advisable to experiment with a small quantity in each batch before subjecting a whole lot to the drawing out heat, which should commence at about 700 deg. fahr. If the scleroscope registers between 50 and 58, the correct hardness has been obtained; if higher than 58, the parts should be reheated to a higher temperature than before; if lower than 50, the parts should be rehardened. After this treatment, the pieces are finish machined. No further hardening is necessary. When machining, slow speeds and feeds must be used.

Hardening after Machining, and the Scleroscope Test. Practically all alloy steels and all low-carbon steels are hardened after machining and finished by grinding after hardening. About 0.010 in. on the diameter is left for this operation. All gears should run true, and to obtain this result not only are the holes ground true with the pitch circle, but the hubs are ground on their faces so they will set square with their shafts when tightened up by nuts. The scleroscope test for 30 to 35 point carbon machinery steel is anywhere from 80 to 90, and for 5 per cent nickel steel for ordinary gears 80 to 85, and for clash gears 70 to 75. All steels are tested by the file in addition to the scleroscope. The file test by an expert is very reliable and some feel that possibly more confidence can be placed on his judgment than on any testing instrument.

The above notes apply to spur and bevel gears. For worm and worm-wheel drives, the worm should be made of machinery steel, casehardened, and the wheel of a hard bronze. Both should run in a bath of oil, especially if under high speed and heavy duty. Spiral gears should be used only where the duty is light. The material should be the same as for a worm and wheel, and they should also run in oil to avoid cutting.

For index mechanisms, where accuracy is essential, if the worm is hardened the thread must be ground afterwards. This is done in all the spiral heads of Brown & Sharpe's make. Generally, the worm, made of tool steel, is left soft. Worm wheels used for indexing purposes only are usually made of cast iron, and invariably if of large diameter. High-multiple threaded worms for indexing mechanisms should not be used; a double thread can be tolerated, but not more, if accurate indexings are required.

DISCUSSION

John Riddell referred to the necessity for correct design in gears and to the attention which they should receive in the process of manufacture in pattern shop, foundry and machine shop.

If the foundry is large so that it can set apart a cupola or a melt in a certain cupola, the results may be all that can be expected from cast gears, but if the foundry is of medium size and makes no particular melt for gears, common cast iron that may be very soft and porous is the result. Cast iron for machine tools and other apparatus generally will vary somewhat with the foundry and even the section of country in which such castings are made.

The writer believes that he was among the first in the United States to use the hobbing process for cutting gears. As originally started there were some drawbacks with the process and there is still something to learn.

Various attempts have been made to improve the indexing device, some of which appear to be very good, but others of which, while eliminating one error, have introduced several other irregularities, and do not seem to have made the general improvement expected by the designer.

As to the other materials outside of cast iron and gun iron, great improvements have been made, due to the automobile and high-speed requirements, such as in turbine engines and the connection of electric motors with machine tools. The latter has been made by the use of cloth pinions.

These pinions seem to have a number of advantages over other types of non-metallic pinions and have proved in a wide variety of applications to have strength about equal to that of cast iron. The Lewis cast-iron formula is used in their design and many users believe that by virtue of their elasticity they withstand service shocks better than cast-iron pinions of the same dimensions. Their life in most applications appears to be a little longer, and their substitution for cast iron on a very large scale is, therefore, only a question of whether their higher cost is justified by their more quiet operation.

The gear may be made of machinery steel or a casting, but the pinion is usually of harder material and very frequently oil tempered, unless cloth or rawhide is used.

Gear boxes should be used in some places but not in others. Sometimes when in a hurry for machine tools, gear boxes are ordered for the initial drive, where ordinarily the writer would prefer to use a variable-speed motor to take the place of unnecessary gear boxes. No matter how well these gears are made they are bound to make too much noise. A gear box for changing feeds and for automobiles, perhaps is necessary at present.

Much is yet to be done in designing machine tools as to gears for driving the machine as well as for giving different feed variations. On feeds of large machine tools, such as planers, and large planer type milling machines, electric motors are being very successfully used, which not only cut out a lot of gears but other mechanisms, and are a step in the right direction. Gears, especially bevel gears, have always seemed a necessary evil, though many attempts have been made to use spiral and helical gears to eliminate some of the difficulties inherent in bevel gears.

The writer would like to urge upon the trade, a more accurate system both of indexing and of mounting gears after they have been properly indexed and cut. If a gear is allowed to have the slightest play on a shaft it will run eccentrically and no matter how little this eccentricity may be there will be a noise which cannot possibly be eliminated.

F. V. McMullin (written). Having had experience in furnishing forgings to gear makers, I can say that today, their specifications are based mostly on chemical composition of the steel, some on physical tests, while a very few give both chemical and physical. For the ordinary gear that

is neither case-hardened nor heat treated, gear makers usually call for 25 to 30 point carbon, no other element being mentioned. If the gear is to have hard usage, they will call for a higher carbon, 40 to 50 point, or even 60 point being demanded; some also specify the manganese, sulphur and phosphorus.

Gears that are to be case-hardened should be made of steel of not more than 20 point carbon, as this more easily takes the case. Some makers still buy 30 point carbon steel for case-hardening, which in my opinion is unwise. When gears are to be oil tempered a 40 to 50 point carbon steel or a 3½ per cent nickel 40 point carbon steel should give satisfaction. A 3½ per cent nickel, 25 point carbon steel is used both with and without heat treating, though I think the latter is not good practice, as such steels should always be treated. Where a gear is to have hard wear and the design permits the use of a thick tooth, high manganese steel will be found satisfactory. One well-known machine tool builder uses a high manganese gear in mesh with a train of heat-treated nickel chrome gears with very good results.

I append a few typical gear specifications from our order files:

a Carbon 20 to 30 point; Phosphorus and sulphur less than 0.04.

b Carbon 0.07 to 0.10; Manganese 0.30 to 0.40; Sulphur 0.035; Phosphorus 0.01, and Silicon 0.01.

c Carbon 0.40 to 0.50; Manganese 0.50 to 0.55; Phosphorus 0.01 to 0.015, and Sulphur 0.035 to 0.04.

d Carbon Steel Annnealed: Ultimate tensile strength 80,000 lb.; elastic limit 40,000 lb.; elongation 22 per cent in 2 in.; contraction of area 35 per cent.

e Nickel Steel, or Nickel Chrome, or Carbon Steel: Phosphorus and sulphur less than 0.04; ultimate tensile strength 80,000 lb.; elastic limit 50,000 lb.; elongation 25 per cent in 2 in.

f Carbon Steel, 55 to 65 Point Carbon: Ultimate tensile strength 85,000 to 100,000 lb.; elastic limit 45 per cent of ultimate; elongation 22 per cent in 2 in.; contraction of area 35 per cent.

A. L. De Leeuw (written). In regard to the use of hardened clash gears, we replaced all soft gears by hardened ones, in our milling machines, not because the soft gears were not satisfactory, but because it was impossible to control the operators handling the milling machines. If the operator would follow the injunction not to throw in the gears when the machine was running, soft gears would have been entirely satisfactory.

One of the speakers said that in general the trade demanded steel gears. This is a clear case of the minority ruling. In 99 out of 100 cases, cast iron is good enough; but in the hundredth case there is trouble; this trouble is noised about, and then the conditions of competition make it absolutely necessary to change over to steel, even though cast-iron gears might have a number of advantages of their own.

In regard to the use of cast-iron gears for slow drives, it has been the experience of a good many engineers, and, to a certain extent, has been my own experience, that the Lewis formula is too conservative for low speeds. Pressures may be used, 50 per cent and, in some cases even 100 per cent, above the figures of the Lewis formula.

I want to call attention to the table Mr. Parker gives, in which he speaks of gears in sets that are non-removable. He mentions that each one of these gears is used at times, thus distributing the wear over a number of gears. This idea may be in the mind of the designer, but whether all of these gears are actually going to be used is a matter over which there is no control after the machine enters the shop of the customer. It may be that a single set of gears will be used all the time.

H. F. L. Orcutt said that in Great Britain the gear box drive is coming in, copying the American practice, and it is recognized that the gear box drive and the single pulley drive are the developments of the future.

The requirements of the London police on the English buses may be interesting. The makers have had to use chain drives in the transmission box to satisfy the demands of the police for quiet transmission. He thought those who had been in London and witnessed the running of the buses could never have heard more quiet transmission.

A. W. Thompson said that he was primarily interested in the manufacture of gears for textile machines and spoke of the satisfaction he had found in the hobbing process for cutting spur gears both as regards economy of manufacture and smoothness of running. In textile work the use of gears with teeth cut at an angle is favored for special purposes where it is desirable to eliminate vibration, for which the hobbing process is particularly well adapted.

E. H. Neff, in reference to the mention that had been made of the demand of the trade for steel gears, said that the user demands a tool which can be used continuously. Inasmuch as steel is stronger than cast iron it will bear more abuse than cast iron and the manufacturer of machine tools is inevitably pushed towards equipping machines with steel gears. The elimination of cast-iron gears, however, will be a matter of many years rather than as a result of any sudden change.

F. DeR. Furman (written). There seems to me to be a pretty close link between item *A* and the different materials that are there given in the third column of Table 1. The author uses the words, "Gears always in mesh, the wear on the teeth being constant." I doubt whether this is a proper expression, because the wear on the teeth, as I see it, is greater at the tips, there being more sliding as the line of contact passes away from the line of centers; and if there is more sliding at the ends of the teeth, naturally there should be more rapid wear at that place. And then, as there is more wear, it leaves the bulk of the work to be done by the teeth on or near the pitch line. Now, if we have a material that is soft enough to wear away fast, under that rubbing action, the pressure between the teeth will take place near the centers of the teeth and the work of transmission will be better done. And if the tooth is made of a hard material which refuses to wear away or to yield readily as the rubbing action takes place at the ends of the teeth, that hard tooth is going to receive more punishment at the ends and more stress in the teeth will be set up than in the tooth made of softer or more yielding material. The center of pressure which produces the greatest stresses in the teeth, travels from the tip of the tooth to the center and back again alternating until the teeth are worn out or until they break, but in the soft or yielding material the most injurious pressure

which is at the tip of the tooth will last for the shortest period of time. Of course, on the other hand, the tooth that is made of hard material is stronger to receive the punishment, but I think in considering the materials that are used, we can get along better if we also consider the action which occurs between the teeth.

C. R. Gabriel mentioned a case of high-speed gearing in connection with automobile torpedo engine construction showing the possibilities of gear drives at high speed and heavy duty. In the torpedo an engine of the turbine type is used to drive the propeller shafts through a balanced train of eight gears, made of chrome nickel steel, case-hardened, the teeth of the spur gears being ground after hardening. These gears work under very heavy duty, considering the proportions of the gears.

The engine develops 125 h.p., but due to the fact that the turbine motors, which run in opposite directions, do not develop equal amounts of power, one set of gears is required to transmit 75 h.p. The spur gears consist of pinions with 24 teeth and gears of 80 teeth, 10 pitch and 1 1/8 in. face, making a ratio of 3 1/3; the bevel gears have a ratio of three to one, the pinions being 1½ in. pitch diameter and the mating gears 4½ in., also 10 pitch. The speed of these gears is very high, that of the spur gears being 7500 ft. per min., and of the bevels 1400 ft. per min., the tooth pressure on the bevels being about 1800 lb.

This construction has been well tried out, several hundred torpedos being fitted with engines of this type. While the length of service is not such as gears in machine tools and automobiles are required to stand, some of these torpedos have made several hundred runs of 8 min. to 10 min. duration, and gears examined after this amount of service showed no appreciable wear. It should be mentioned that these gears are never subjected to shock, as the engine starts with an accelerated motion, and the load is practically constant throughout the run. In operation these engines are very noisy, but in torpedos this is not an objection, as when submerged in the water the noise is not heard.

The Author. In regard to the remark of Mr. Riddell, that he did not like the variable speed mechanism in his machines on account of the noise and the use of gears in general, I believe the spindle speed gear box to be one of the best things we ever put in milling machines. We find that we can do about four times the work in the milling machines by the constant speed belt drive and variable speed mechanism, than with the old cone pully belt drive. As to the noise, we have no trouble in the milling machines made by the Brown & Sharpe Manufacturing Company; the hardened gears run very nicely and quietly.

Regarding Professor Furman's criticism of the gear conditions specified in class *A*, what I meant as to the wear of the teeth being constant was that the teeth are always engaged, and there is no moving from one gear to another, such as the gears in the milling machine knee, where they are always in action when work is being done.

Mr. De Leeuw's statement that the hundredth case might be using only one speed is very true; but I have treated this subject in a general way. Of course, we have different conditions to meet and the machines are designed for the general run of the trade.

CAST IRON FOR MACHINE-TOOL PARTS

By Henry M. Wood, Cincinnati, Ohio

Associate Member of the Society

ABSTRACT OF PAPER[1]

In the belief that valuable information could be secured by a comparison of the present practices of representative machine-tool manufacturers, the writer asked a number of machine-tool makers in different lines and in different sections of the country if they would be willing to submit an outline of their practice. The following excerpts pertaining to the mixtures used and chemical analyses of the castings are quoted from their replies:

A Builder of Special Machine Tools: Our iron is bought on analysis specifications, covering two grades as follows:

Two Plain	
Silicon	1.75 to 2.25
Manganese	0.60 to 0.90
Phosphorus	0.50 to 0.80
Sulphur	0.50 and under
No. 3	
Silicon	1.00 to 1.50
Manganese	0.50 and over
Phosphorus	0.50 to 0.80
Sulphur	0.07 and under

In addition to the above we use materials as follows: No. 1 machinery scrap, mild steel scrap, manganese steel scrap. The last carries 12 per cent of manganese with quantities of the other elements so small that they are negligible in gray iron foundry work.

Our mixtures are figured out on the actual analysis of each bar, insuring in the castings uniformity of analysis and consequently of physical characteristics, such as strength, density, and machining qualities. In general practice we use three different mixtures suited to our varying needs.

In our first mixture we include our lighter castings such as pulleys, small gears, washers, hand-wheels, brackets, and the like. In this mixture we endeavor to have the following analysis:

Silicon	1.90
Manganese	0.60
Phosphorus	0.70
Sulphur	0.08

This is usually secured by the use of a mixture of 50 per cent of two or three lots of two plain iron and 50 per cent of scrap. The proportions of the different pig irons are adjusted to produce the proper analysis in the mixture, and the scrap is partly our own foundry return and the balance No. 1 machinery scrap.

Our second mixture covers all our heavy work, such as planer beds, posts, tables, face plates, frames, etc. These castings require strength and sufficient density to permit the

[1] Published in complete form in the November 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the Annual Meeting, December 1913. Pamphlet copies may be obtained: price, 5 cents to members and 10 cents to non-members.

machined surface to take a high polish. These ends we accomplish by an analysis as follows:

Silicon	1.40
Manganese	0.60
Phosphorus	0.60
Sulphur	0.09

This mixture consists of 45 per cent of two or more No. 3 irons and 55 per cent total scrap, shop and No. 1 machinery together. Should this mixture fail to yield sufficient manganese the addition of 1 to 2 per cent of manganese steel scrap is made to correct it.

The third mixture is semi-steel, used principally for large blank gears and castings requiring special strength. Its analysis is

Silicon	1.20
Manganese	0.90
Phosphorus	0.45
Sulphur	0.09

Its average makeup is

	Per Cent
Machinery scrap	30
Mild steel scrap	20
Manganese steel scrap	5
No. 3 pig iron	45

The above mixtures cover our entire range of work except cases where some special composition is required or desired.

A Manufacturer of Precision Machinery: In our work we run various grades of iron to meet the conditions existing in the machines or in the parts of machines under consideration.

In a general way our mixtures, in per cent, run as follows:

Silicon	Manganese	Phosphorus
3.00	0.60	0.80
2.40	0.65	0.70
2.00	0.65	0.60

The first is for the average run of castings of smaller size; the second for the larger castings. Where we need a special close-grain iron we use the third mixture.

A Manufacturer of Milling Machines: We have never carried on any extensive experiments to learn the best mixtures of cast iron for our purposes. We use in the tables, knees, saddles and vises about 20 per cent of steel with a view to obtaining a close-grain casting, and increasing somewhat its strength.

We use practically no cast iron for gears or small parts, these being made of steel drop forged in the case of larger parts, and also in the case of smaller parts when not adopted for manufacture from the bar.

The ideal casting is, of course, one that is so close as not to show any grain when finished and at the same time, just as hard as it can be, and be worked into shape.

The question of strength is probably not so important, as there is opportunity to use sufficient bulk to obtain strength. At any rate this is true of the parts that we make of cast iron, for, as stated above, all our gears and like parts are made from steel which is casehardened.

A Manufacturer of Heavy Lathes: With the heavier castings we are using a semi-steel mixture with about 20 per cent of steel. The analysis of this iron shows 1.60 to 1.70 silicon, 0.65 to 0.75 manganese, 0.40 phosphorus, 0.8 to 0.10 sulphur. While our carbons are not noted as a rule, we get a check on these every once in a while, showing the total carbons about 3.50 to 3.60.

Our iron for smaller pieces runs from 1.80 to 1.90 in silicon, 0.40 to 0.50 in phosphorus, 0.65 to 0.70 manganese, 0.07 to 0.10 in sulphur. The total carbon shows up practically the same in both mixtures. Our test bars on the first mixture break at from 2800 to 3200 and on the latter mixtures at about 2600. This refers to 1 in. by 1 in. standard bars supported on 12 in. centers.

A Manufacturer of Grinding Machines: We use castings with various proportions of steel according to the size of the casting and the place where it is to be used, so that today we have very bright lustrous surfaces and it is possible to get accurate alignment.

PRACTICE WITH REFERENCE TO CHILLING CASTINGS

There is a wide difference of opinion among machine-tool manufacturers as to the desirability of chilling any surfaces of castings. In view of these differences and the idea held by some that it is impossible to chill an iron of high tensile strength without making it so hard it cannot be machined, the practice of the Lodge & Shipley Machine Tool Company, with which the writer is connected, is here outlined. Three average analyses are as follows:

Silicon	Sulphur	Phosphorus	Manganese	Tensile Strength
2.16	0.065	1.01	0.40	22,310
2.17	0.065	1.01	0.39	24,840
2.45	0.076	0.63	0.71	24,195

The first analysis is of a specimen taken in January 1913 from the first iron run in a heat; the second, from the last iron of the same heat; the third, from the average iron of a heat in September 1913.

This same iron is used for lathe beds of which the ways are chilled, also for other cast-iron parts which do not require the high tensile strength of semi-steel. For some parts, such as compound rest top slides and reverse plates, we use semi-steel. Parts subject to greater stress or to severe shock are made of steel.

The Effect of the Chill on a casting is well shown in Fig. 1. This shows the cross-sectional fracture through the finished ways and a portion of the side wall of the chilled bed for a 30-in. lathe. The reproduction clearly shows that the iron even far away from the chill in the side wall of the casting is dense and of as close grain as other good cast iron; it also shows the much closer grain of the iron below the finished surface as a result of the chill in closing up the iron and making it harder and more durable. In the 30-in. bed, as plainly shown by this specimen, the close iron produced by the chill extends to a depth of 1½ in. to 2 in. below the finished surface of the ways, thus proving that the chilled iron is not all removed in the planing.

Degree of Hardness. Scleroscope test on chilled beds finish planed but not scraped gave as a result of eight different tests on four different beds, scleroscope readings of 40 to 42 with an average of 41. Similar

tests on chilled beds which had been planed and then scraped gave a practically constant scleroscope reading of 42. Comparative scleroscope tests on a heavy section of unchilled cast iron which would give as nearly as possible conditions parallel to those just quoted gave readings ranging from 18 to 22, with an average of 20. These tests indicate that the chilled ways are much harder than the unchilled.

Action of the Chill. The chilled surface is produced by a series of cast-iron chill plates each about 6 in. long placed end to end in the mold. The use of separate short plates eliminates much of the warping and twisting which would occur in a long chill plate.

If a thick chill plate is used with a low-silicon iron the surface of the casting is chilled so hard that it cannot be machined. The desired result is attained by regulating the thickness of the chill plate to suit the size of the casting for which it is used; then a low-silicon iron of high tensile strength can be successfully poured. The heavier the casting, the thicker the chill plate.

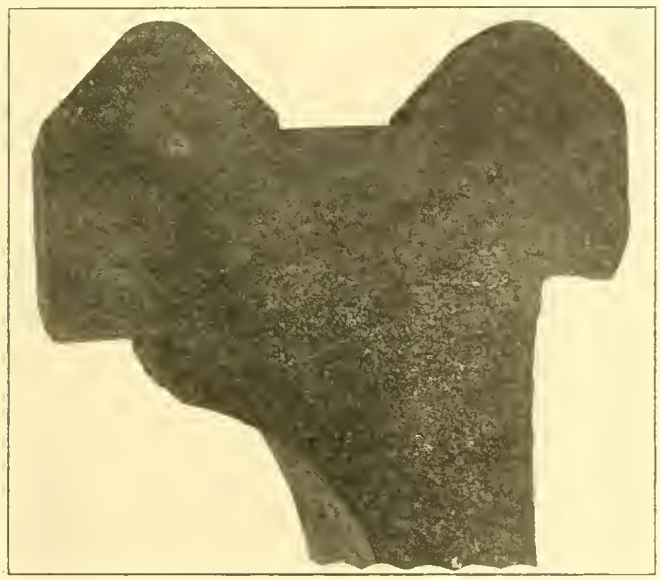

Fig. 1 Cross-Sectional Fracture of Chilled Lathe Bed

The action in the mold is that when the molten iron strikes the cold plate it is chilled and hardened; then the heat in the mass of iron forming the body of the bed casting gradually warms the chilled surface and the chill plate, thus annealing the casting or "drawing the chill," just as when in tempering a chisel the heat in the shank of the chisel "draws the temper" of the cutting edge to the proper point after the cutting edge has been hardened by quenching in water. This annealing of the chilled surface of the casting produces the desired form of hard, close-grained gray iron.

The thickness of the chill plate used is such that the heat in the casting will anneal the surface sufficiently to permit planing, although at a greatly reduced cutting speed, and yet retain the benefits of the chill.

The advantages of chilled wearing surfaces for machine tools are:

a Much harder surfaces, which experience has proved are vastly more durable than similar unchilled surfaces.

b A hard guiding surface with a relatively soft carriage, bringing the bulk of the wear on the carriage and thus maintaining the alignment of the guide.

c A denser and much more closely grained surface of the casting, giving better appearance.

d An exceptionally smooth finished surface, in which there are no pores where dirt and grit may become imbedded to cause rapid abrasion of the other bearing surface.

Chilled surfaces are more advantageous on some machines and some parts than on others. In the case of a lathe the carriage will often be used for long periods of time on chuck work or on short jobs between centers which brings all of the wear on a comparatively short length of the bed just in front of the headstock; such uneven wear on the unchilled bed destroys the accuracy of the alignment for long work. Chilling the ways brings the wear principally upon the carriage, and even if the carriage is worn, the alignment at all points along the bed will remain relatively true.

Our experience, based on the use of chilled ways on beds of all sizes of our lathes for more than two years, is that no internal stresses are created by the chilling; that the surface is not made more susceptible to a peening action; that the surface can be equally as well lubricated as before; that iron of high tensile strength is used; and that the increased hardness and closeness of grain of the chilled surface vastly increases the durability and permanency of alignment. We find no disadvantage except a somewhat increased cost.

DISCUSSION

W. Wallace McKaig[1] called attention to the mixture for heavy lathe of semi-steel, the analysis of which is Si, 1.60, Mn, 0.65 to 0.75, P, 0.40, S, 0.8 to 0.10, given in the paper, and said that there seemed to be a very wide latitude in the sulphur. Furthermore, an iron with sulphur in the proportion of 0.8 would be white hard all the way through and would be impossible to machine. An iron of the above analysis with sulphur as low as 0.3 would also be white hard. He would appreciate information as to a way of making a 20 per cent semi-steel with sulphur in the proportion of 0.8, in which the castings are soft enough to machine.

A. Lewis Jenkins wrote that most machine tools are required to resist deflections and vibrations, and when sufficiently rigid and massive to satisfy these requirements there is practically no danger of breakage. About the only ma-

[1] With Merwin McKaig, Cumberland, Md.

chine tools designed for strength in which the deflection may be neglected are shears, punches, presses and hammers.

Beds and carriages of lathes; housings, cross-rails, tables and beds of boring mills; columns, and knees of milling machines and shapers; columns, arms and tables of drilling machines, are examples of machine parts requiring stiffness; they never break. The very lowest grades of iron would be entirely satisfactory for these parts from the standpoint of strength, provided the parts were sufficiently heavy to resist the vibrations and deflections caused by the pressure of the tool.

The ultimate tensile or the transverse strength of a test bar is of no greater value in proportioning some parts of machine tools than the specific gravity of the material.

The most important physical property that may be determined by a test is the deflection under a load equal to about 1/10 of that required to break the bar, or about 250 lb. at the middle of a 1 in. by 1 in. bar on supports 12 in. apart. It would be better to use a bar that is at least 24 in. between supports in order to get accurate deflection readings.

Hodgkinson's Experimental Researches (1860) gives the ultimate breaking load and the modulus of elasticity at a load of 112 lb. for about 250 bars 1 in. by 1 in. by 54 in. between supports. Plotting the breaking load against this modulus of elasticity (at 9072 lb. per sq. in. transverse stress) showed no definite relation between the ultimate transverse strength and the elastic properties. It is also evident that no relation exists between the deflections at 112 lb. and at rupture.

In view of these results neither the ultimate strength nor the ultimate deflection of a test bar is of any value in determining the most essential property of the material.

The values of the moduli of elasticity in Hodgkinson's results vary from 11,539,333 to 22,733,400, which means that if a casting were made from each of these materials one might have a deflection twice as great as the other. The variations in the elastic properties of the iron may cause an appreciable effect on the accuracy of some machine tools.

Complicated castings should preferably be made from metal having a small shrinkage, thereby decreasing the initial stress due to cooling, warping, shrinkage cavities and some of the visible defects commonly seen on finished surfaces.

It is not an easy matter for some foundries to get a mixture that will produce desirable machining properties and have a grain sufficiently close to take a high finish. Good results in this respect have been accomplished by the use of charcoal, certain grades of coke, steel scrap and ferro-alloys.

In the selection of castings the machine tool builder should consider, together with the machining and finishing properties, that property of the iron which resists deflection and upon which depends the stiffness and corresponding accuracy. The ultimate strength is a minor consideration.

Thomas D. West referred to the difficulty experienced by one manufacturer who had replied to the inquiries sent out by the author that he had had trouble from the scratching of chilled ways used on machine tools through some little particle of metal which had settled on them.[1] Mr. West suggested that the chilled surfaces might have been wavy or streaked so as not to present a smooth homogeneous surface; and that the trouble might be due to the failure to use a varnish to coat the chillers with.

All chillers generally require to be coated with wet blacking which must be dried; oils, chalk or other coverings that do not require any heat drying are also used. For the purpose of lathe ways and chiller plates or blocks the following recipe is the best the writer knows of and has not to his knowledge been heretofore published. It is what some of our leading carwheel makers use to obtain the perfect surface seen on the threads of their wheels which wear smooth without causing any scratches.

Suitable proportions for this varnish are shellac, 34 lb., lamp black, 4 lb., wood alcohol, 9 gal.; or if a smaller quantity is desired the mixture in the same proportions. The alcohol is put into a barrel with the shellac to cut it up well, so that it will be entirely liquid before putting in the lamp black. This alcohol costs 50 cents per gal. and is 95 per cent alcohol. Recent experimenting has led to the use of mineral blacking or dust, obtained from foundry companies, in preference to the lamp black, as it gives a smoother skin to the chilled face, does not gum the chillers

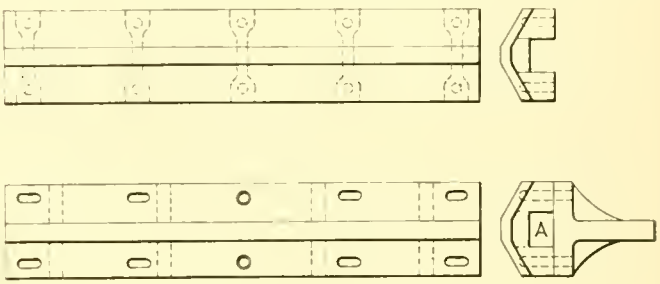

Fig. 2 Chiller for Latheways

as the lamp black does, and only about half as much is required.

Should the face of the chillers show signs of any roughness or scale other than that caused by the varnish, some dry sand is rubbed over it with waste, or emery or sand paper may be used. The varnish is applied with a brush, and the chillers are given one coat and then allowed to dry in the open for twenty to thirty minutes. On top of this coat of varnish a thin coating is applied, composed of half kerosene oil and half common black oil, and on top of this again a little mineral blacking is dusted on to prevent the oil and kerosene mixture from forming streaks and to keep it in a smooth body. The dusting is done by shaking it through a hand bag, such as is used by stove molders and general foundrymen for shaking general dry blackings on their molds. This last coat requires only about 15 minutes to dry, after which the mold having the chillers can be poured.

The author mentions the use of a series of cast-iron chiller plates, placed end to end in the mold to eliminate the warping and twisting which is liable to occur in a long chiller plate. Mr. West, however, believed that foundrymen would prefer to use one continuous chiller piece, provided its warping could be prevented, and suggested that where long chillers are desirable, they be made no thicker than necessary to give the required depth of chill, and that means be arranged for bolting a chiller plate to a rigid casting or beam of sufficient stiffness and strength to keep the chiller plate from

[1] See complete paper for reference—Editor

warping. Fig. 2 indicates such a construction. The upper view shows the chiller plate and the lower view a T-shaped beam with the plate bolted to it. The elongated bolt holes in the beam allow for expansion. The bottom of the lugs of the chiller plate and the face of the beam should be planed to unusual straightness and the chiller casting can be made either of steel or wrought iron, since there is practically no difference in the chilling qualities of these two metals, as indicated by the writer's experiments.[1] An air space should be allowed at *A* (Fig. 2) which may be left open or filled with rammed sand or other material of low heat absorbing quality; or water or air pipes may be inserted in this space to retard a "drawing of the chill" and to eliminate the possibility of the beam becoming heated to such an extent as to cause its warping.

Forrest R. Jones sent the following excerpt from his note book as of value in relation to the durability of flat rubbing surfaces of cast iron. The stationary member is referred to as the "guide," and the moving member as the "block."

Alfred Herbert, Ltd., Coventry, England. Visited September 5, 1902.

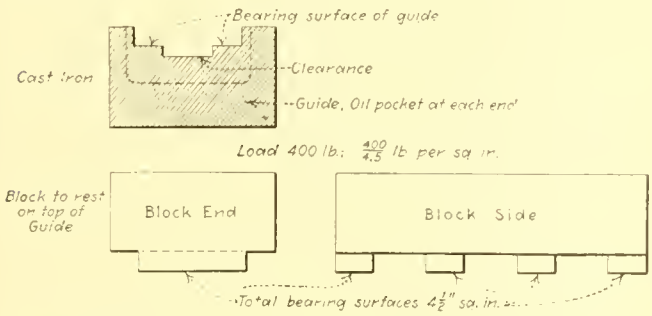

Fig. 3 Block and Guide for Testing Rubbing Surfaces

Experiments had been made on flat rubbing surfaces of various kinds of cast iron. Both surfaces always of the same iron. The bearing surface of the guide a narrow strip along each side; block held in place by the upper lips of the guide. Middle of guide cut away for clearance. Oil pocket at each end of guide. Block has narrow strips across its length; ends of cross-strips rest on the bearing strips of the block.

No oil-grooves or indentations (other than the pores of the metal) in the bearing surfaces. Enough oil used to act as a bath.

Each block was run (slipped) back and forth 84 miles on its own particular guide. Hardness was tested by drilling.

Softest metal by drill test showed best wearing qualities. The softer metals were the more porous.

After 84 miles of slipping the softer metals showed practically no wear; the scraper marks still remained on both block and guide. The oil remained clear. Harder blocks showed considerable wear. With them the oil soon became black, almost as black as ink.

Total bearing surface of block, 4½ sq. in.; total load, 400 lb., bearing pressure $= \frac{400}{4.5} =$ 89 lb. per sq. in. nearly.

At a date some eight or ten years earlier than that of this memorandum the Aermotor Company of Chicago found that a thoroughly chilled cast-iron bearing would far outlast any other of numerous materials used for the bearings of the horizontal shaft of the vane wheel of their windmills. These bearings were generally neglected as to oiling, and before the chilled cast iron was adopted, gave trouble by rather rapid wearing out when thus neglected. The cast iron used for the aermotor bearings was chilled hard and white, like a car wheel, a roll for a steel mill or a flour mill, or the mold-board and point of an agricultural plow. The shaft was of ordinary machine steel.

A few years ago, the writer had occasion to test the durability of chilled cast iron as a bearing surface when rubbing against tempered spring steel as the mating bearing surface. The coiled spring gripped the entire circumference of the round cast-iron member. The cast iron used was chilled hard and white. After the surfaces had slipped over each other more than 40 miles actually measured, and probably half as much more not measured, under all conditions of lubrication and the lack of it, at a bearing pressure more than 300 lb. per sq. in., the chilled iron still showed the marks of the fine-grained emery wheel that had been used to grind its friction surface.

E. H. Mumford (written). Speaking of this question wholly from the foundry standpoint, it occurs to me that too much stress is commonly laid on the strength detail of cast iron for machine tool uses, considering the use to which it is put after it gets into service, other than in gears. In my steam pump experience I used Keep's test quite extensively, with more attention to the shrinking and chilling tendencies than to the strength tendencies; I try to use a uniform test bar so as to get absolutely relative results. It is undoubtedly true in the use of cast iron that its strong tendencies to shrink in certain dimensions in rigid castings develop stresses which lead almost to fracture before the real load comes on, so that strength is a minor consideration under the circumstances.

I do not refer to the form of shrinking which produces honeycomb spots in the center of joining parts as where pump diaphragms join the side-walls, or spokes join wheel rims and hubs, and which are known as "shrinks" or "draws" in the foundry, for that is a different matter. Castings are weakened more by cooling stresses due to shrinkage than by lack of intrinsic strength as shown by breaking tests, either transverse or tensile.

I had supposed that it was well known that such chilling as Mr. Wood refers to in his paper is entirely different from that in car-wheel or roll or cylinder castings, but the comment made by manufacturer No. 34 seems to show that there is some misconception of what chilling means in the sense in which Mr. Wood has used it in his paper. It should be clearly understood that the chilling referred to bears no relation to the chilling of car wheels or rolls made from low silicon iron.

The quick cooling of high silicon iron on running against a chill prevents the segregation of graphitic carbon in large masses and holds the iron to a closer texture without any such hardening of the surface as interferes with proper machine cutting; whereas, with low silicon iron, the surface, and for considerable depth below it, contains no graphitic carbon whatever and can be touched only by a grinding wheel or the special chilled tools used in roll turning.

[1] New Processes for Chilling and Hardening Cast Iron, Trans.Am.Soc.M.E., vol. 34, p. 235.

Bradley Stoughton. I think the Society should be congratulated upon this paper, and upon the method which was followed in writing it, whereby the opinion is obtained of several men who have had experience in these matters, and who are willing to give anonymously the benefit of their experience.

I want to call Mr. Wood's attention to the natural alloys of iron, nickel and chromium smelted from the Mayari ores of Cuba. I think Mr. Wood will find that they have been used to some extent in machine tool work.

A. L. De Leeuw (written). I want to call attention to the following statement contained in the paper: "The ideal casting is, of course, one that is so close as not to show any grain when finished, and at the same time be just as hard as it can be, and be worked into shape." I want to warn against the "of course," which seems to take it for granted that we all agree with it. I believe it is a little bit early to agree entirely with this statement. We like to have the appearance of the casting close-grained, but it is doubtful if the close-grained casting is always the most serviceable. Experiences of other people, and some of my own, have shown that the presence of graphite in the casting is of decided benefit; especially if the graphite is near the top after the scale has been removed. This may be the reason why soft blocks wear better than hard ones.

Another thing touched upon in the previous discussion is that it may be advisable to have different hardnesses in the surfaces which wear together; Mr. Wood indicated that it is well to have the lathe bed harder than the carriage. We cannot get away from the wear. The number of cases where this wear is so small as to be negligible are so rare that we may just as well make the general statement that we must provide for the natural wear of moving machine parts. I would suggest that Mr. Wood's statement be broadened out, and that we say that we should make the part which guides, harder than the part which is guided.

The point which was brought out in the discussion in the preceding paper on gears is, that in the softer cast-iron gears there is naturally a wearing at the point of the teeth, and that when this point is worn sufficiently, the wear will then come naturally on that part of the tooth where it should be. I wish to call attention here to the fact that if the gear is of such softness that the point wears away, then, after the pressure has come to the center, the center will wear away, and then the pressure will come on the point again. I really do not believe that any such kind of action takes place, but rather that there is an undue wear over the entire tooth if the material is too soft. I believe that in order to avoid the excessive wear in gears, the proportions and sizes of the bearing surfaces, and the hardness of the materials, should be as ample as we can make them.

There are certainly a great many pieces where chilled castings can be used to great advantage, and not only for wearing surfaces. This refers especially to T-slots. In most machines, practically all except the very largest, T-slots are finished out, which makes the under side of the lip of the T-slot rather soft. Chilling this T-slot will condense the material, and prevent the lip of the T-slot from swelling unduly when fixtures or pieces of work are clamped down.

D. J. Riggs wrote that the author has referred to chilled iron as that which cannot be planed, filed or scraped; and this is the common conception amongst us. But we all know that some foundry irons will hardly chill at all and that other irons may be found anywhere between these two extremes. It seems that in applying chills to lathe beds, the author has not gone to the extreme limit of hardness. In the case cited where there was trouble from the scratching of chilled ways, they have probably either used an iron that chilled too easily, or used too heavy a chill. After getting the iron too hard they have undoubtedly resorted to the use of loose emery and left some of it imbedded in the iron to make trouble later.

The Author wished to present no closure.—Editor.

A RECORD OF PRESSED FITS

By C. F. MacGill, St. Louis, Mo.

Member of the Society

ABSTRACT OF PAPER[1]

In my own experience, covering about 20 years, in charge of shops where forced fits were made, I have found that it was not necessary to increase the allowance with the diameter of the shaft, as the increased surface area of the fit added sufficient friction to bring the pressure up to the required tonnage, and that an allowance of from 0.002 in. to 0.004 in. on steel shafts pressed into steel hubs, and an allowance of from 0.003 in. to 0.005 in. on steel shafts pressed into cast-iron hubs of ordinary hardness, gave good results. I have yet to learn of one of these shafts coming loose.

There is no doubt in my mind that allowances greater than 0.006 in. on steel shafts pressed into cast-iron hubs, not only do not serve any useful purpose, but tend to set up strains that are injurious to the casting.

One large plant with which I am familiar issues an allowance table for pressed fits, the allowance gradually increasing with the shaft diameter. This is not followed in their shaft department, but instead a flat allowance of 0.003 in. is used without regard to the diameter of the shaft.

The table, published with the complete paper, covers 206 fits of diameters varying in size from 3.5 in. to 20 in., sufficient in range and number to demonstrate the correctness and value of the practice followed. The records are all of fits made on electric generators and motors and show the diameter of the shaft, the diameter of the bore, the length of the seat, the diameter of the hub, the material of which the hub is made, the allowance (the difference between the diameter of the shaft and the diameter of the bore of the hub into which the shaft is expressed), the pressure in tons required to force the shaft in, the maximum tension stress in the bore in pounds per square inch, the radial

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pressure on the surface of the shaft in pounds per square inch, and the coefficient of friction.

In calculations relating to the subject the following formulae are used as developed by Prof. A. Morley and published in Engineering, August 11, 1911:

Total tension stress at bore of hub:

$$f_t = \frac{\frac{J}{D} \times E}{\left\{\left(\frac{m-1}{m} + \frac{1}{m_1} + \frac{E}{E_1}\right)\frac{R_1^2 - R_2^2}{R_1^2 + R_2^2} + \frac{E}{E_1}\right\}}$$

Normal pressure on surface of shaft:

$$P_2 = \frac{\frac{J}{D} - \frac{f_t}{E_1}}{\frac{m-1}{mE} + \frac{1}{m_1 E_1}}$$

Coefficient of friction:

$$\mu = \frac{P}{P_2}$$

The notation used is given in the original article.

DISCUSSION

JOHN E. SWEET. During the last third of a century at the works of the Straight Line Engine Company, Syracuse, N. Y., we have had experience on a kind of forced fits different from that of Mr. MacGill, and with results that will, I fancy, surprise him and others.

Our crankshafts were made by using two flywheels with very large bosses for the throws of the crank, and, in forcing the crankpins in these bosses out of the center, and in forcing in two pieces to form the shafts. These shafts and cranks were of Coffin treated steel, forced into the cast-iron bosses, and these forced fits were without keys. The size of the crankpins varied from 3⅞ to $5\frac{15}{16}$ in., and the shafts varied from 3⅜ to 4¾ in. The allowance for the fits was after we learned the trade, about 0.0015 in. to the inch, and another thing we learned was that while the boring and turning was very carefully done there would be a little wearing away of the ridges at the parts that first entered, so that to get a rigid bearing at the shoulder, the fit of the shaft was given 0.001 in. taper.

To give some idea of the permanence of these connections, we turned out thousands of these fits, and, in cases where 4¾-in. shaft fits without keys were coupled to generator shafts, where the shafts in the armatures were 6 in. or more, and with 1½-in. keys, the fits in the wheels never slipped. Where the holes are reamed and the shafts are ground, two-thirds as much allowance is ample, and, where the shaft and boss are both steel, it is likely that one-half as much allowance will do, and that is dependent on the length of the fit whether turned and bored or reamed and ground fits.

Ought not a shaft 8 in. in diameter take a pressure four times as great to make a good force fit as one 4 in. in diameter? Will the same allowance give this? Mr. MacGill's table only shows twice as much. There is four times as much surface in the 8-in. size as in the 4-in., even though only the same length of fit.

SANFORD A. MOSS. Mr. MacGill's mathematical methods are undoubtedly correct. However, his values of force for pressing and the corresponding values of coefficients of friction seem very high. There is great variation in the individual cases of the table, but this always occurs. I have many records similar to those of Mr. MacGill's and they vary as much. These are for steel hubs on steel shafts and I have given their general average in a paper on this subject.[1] This led to a coefficient of friction of about 0.038, which is to be compared with Mr. MacGill's average for steel hubs of about 0.12, a difference of 300 per cent. To take actual cases, the average of a great many tests of pressure to force car wheels on axles with about 5-in. bore and 6-in. length of hub, with an allowance of one mil per inch, is about 20 tons, and with an allowance of two mils per inch is about 40 tons. Mr. MacGill's table includes a great many cases of steel hubs from about 4.5 in. to 5.5 in. with an allowance of one mil per inch and his average pressure is about 50 tons. In the paper previously alluded to, an average test figure was given for force to press a rather thick steel hub, of 1560 lb. per inch of bore and per inch of hub length, for an allowance of one mil per inch. This gives for the above wheels with one mil per inch, about 23 tons. I know of some cases where values about 40 tons have been actually obtained, and they have been ascribed to inaccuracies of machine work of hub and shaft.

The test on which the figure 1569 was based and those giving the value of 20 tons force were with ground shafts and carefully reamed holes. A shaft or bore with ordinary machinery may be out of round or out of straightness or have other irregularities amounting to several thousandths.

Possibly Mr. MacGill's coefficients and forces are for ordinary machinery, and the lower values are for cases, with greater accuracy. The lower figures given are for lubrication with white lead or something similar. It is to be presumed that Mr. MacGill used a lubricant.

The formulae and methods used in the paper already quoted are identical with those of Mr. MacGill. In the writer's paper the case taken was for a solid or hollow shaft with a steel hub. Mr. MacGill takes a solid shaft with hub of any material, and values for a steel hub equivalent to the above are obtained by using steel coefficients. Mr. MacGill used 0.25 for Poisson's ratio. The value is probably nearer 0.30, but the effect is very small.

Mr. MacGill rightly concludes that large force fit allowances are not necessary in usual cases. However, in cases where they are necessary, as in high-speed wheels, they cannot be objected to because of excessive hub stresses unless the formulae show large stresses. For proportionately thick hub, the stresses with one mil per inch of bore allowance, are the same regardless of diameter.

It is to be noticed that the maximum effective stress in the hub is not simply the tangential stress, but is shown by the maximum shear theory to be the sum of the tangential and radial compressive stress. This is $\frac{EJ}{D}$ when shaft and hub are of the same material. The sum of Mr. MacGill's stresses will be found to be $\frac{EJ}{D}$ for steel. It may also be

[1] Increase of Bore of High-Speed Wheels by Centrifugal Stresses, Sanford A. Moss, Trans.Am.Soc.M.E., vol. 34, p. 909.

noted that the ratio of the radial and tangential stresses when hub and shaft are alike is

$$\frac{R_1^2 - R_2^2}{R_1^2 + R_2^2}$$

Harry M. Lane wrote that his company's records comprise data upon about 10,000 pressed fits, which go back about 20 years, and he had found it gratifying to note that they embrace all the data possible, there being 24 facts recorded with regard to each pressed fit, including diameter and length of hub into which the shaft is forced, and material of which the hub is made, area of fitted surface and the pressure at the first, second, third and fourth quarters of the length of the fit, which show the effect as recorded by the pressure of varying lengths of fit in each particular case without requiring comparison of different tests.

Before making these records they sometimes had trouble with loose cranks and crankpins, but since beginning the records these troubles practically ceased.

In common with others, they used to attempt additional security in the fastening of crankpins by riveting the pin over at the back of the crank, by screwing it up at the back with a thin, fine-threaded nut or by driving a taper key through slots in the crankpin and its boss

Of course, if the pin does not fit the hole, none of these makeshifts are effective, and if the crankpin is a fit, they are unnecessary. For last twenty years it has been the company's practice to make a dependable fit of the crankpin and let it go at that.

John Riddell spoke of the necessity experienced in the practice of the General Electric Company for varying the allowance for fits in order to meet the conditions existing. In the case of turbine engines it might be necessary in some cases to make a much greater allowance, due to the high speed at which the turbine was to operate, with consequent expansion of the wheel, than in another case where the turbine was to run at slower speed. As a specific instance, on a shaft 23 in. in diameter, an allowance of 0.020 in. was made for the fit. On this particular piece of apparatus it was calculated that when it revolved at 20 per cent above normal speed, the bore would become 0.017 in. larger, or in other words, there would be 0.003 in. left for fit at this speed.

This phase of the subject was treated by Mr. Sanford A. Moss[1] of the company's works at Lynn, Mass., who has gone into the matter carefully and treated it mathematically.

A. B. Carhart (written). It may be proper to suggest that in making calculations for forced fits, the surface of the contact area is a very important factor. The formulæ assume contact of the entire area of the shaft and of the bore. We all know how seldom this is actually realized in practice, because of the irregularities of any machine operations. In railroad shops, in the pressing on of car wheels it is surprising to see the approximation to accurate size and taper that will sometimes pass for satisfactory work and be forced into a fit. I cannot believe that in some cases any considerable part of the total area is actually in contact; yet some of such forced fits prove themselves to be reliable, durable and dependable in service.

More exact information should be required concerning some forced fits as for example in the pressing of car wheels upon axles for use in transportation service. I believe that formerly there was ground for complaint concerning wheels that would either work loose or would split in the hubs, and the manufacturers were called upon to replace wheels claimed to be defective or to pay the expense resulting from failure. Consequently it became of great importance to them to show that the workmanship in any case was satisfactory and that the fit was proper. It was necessary to know that there was proper area of contact, that sufficient power was applied to insure a permanent job, and especially that the pressure was not so excessive as to cause strain within the hub. It is as serious and as troublesome to have car wheels crack from over pressure in making pressed fits, as it is to have them run loose; either fault is a serious one.

Consequently it is now common practice to have a record made in the shop of each fit at the time it is pressed on. Special recording gages are used, which automatically trace a diagram of the pressure applied at each stage of the fit, indicating at the same time the forward movement of the ram of the press that forces the axle into the hub of the wheel. The record begins when the first contact is made, where the pressure begins to be appreciable, and as the axle moves forward, in pressing on the wheel, or in any shaft fitting, the actual gage pressure is recorded at each inch of movement, until the wheel comes to the shoulder or to the final position, and the maximum thrust applied there is also recorded. Such a chart record can be filed away, marked with the number of the job and of the wheel, and the shop has proof, in the future, of a proper and accurate fit, or of any sudden rise in the pressure at any point owing to a jam due to irregularity of the taper or to inaccuracy of the diameters concerned in making the fit.

The Author. The original object of my paper was to prove that "it is not necessary and may be dangerous to increase the allowance on pressed fits, with the diameter of the shaft." As stated, the tension stress, radial pressure and coefficient of friction were calculated some time after the records of the fits were made. The calculations were made primarily to arrive at a proper basis for establishing standard force fit allowances for ordinary machine shop practice, where high centrifugal forces and extremes in temperature need not be taken into consideration. In my judgment the results of these calculations uphold my claim.

I am pleased that the formulæ used meet the approval of Mr. Moss. For the sake of simplicity Poisson's ratio was taken at 0.25 for both cast iron and steel, since the use of different values has no appreciable influence on the result. The value of E for cast iron was kept constant at 15,000,000 partly for the same reason, and partly because where greater allowances are used and E diminishes, these allowances will bring the cast iron into the region of dangerous stresses, especially if hard key driving should be added to excessive allowances.

As to the coefficient of friction it is somewhat difficult to draw reliable conclusions from the figures obtained by the formula used.

Mr. Lane is the author of the paper referred to in the following quotation: "In but one of the papers noticed is there any reference to the diameter and length of the hub into

[1] Increase of Bore of High-Speed Wheels by Centrifugal Stresses, Trans. Am. Soc. M. E., vol. 34, p. 895.

which the shaft is forced or the material of which the hub is made."

In answer to Professor Sweet's question: "Ought not a shaft 8 in. in diameter take pressure four times as great to make a good force fit as one 4 in. in diameter? Will the same allowance give this?" I think not, and my records show that it does not. If this were the case an allowance proportionally less would be logical.

In all cases the surfaces of the fits covered by my table were lubricated with white lead and linseed oil before being pressed together. Too much care cannot be taken in making the surfaces of the fit true and smooth and in the keeping of an exact record of each fit made, possibly with a diagram showing the pressure at different stages as suggested by Mr. Carhart and Mr. Lane.

STANDARDIZING MACHINERY

By Fred H. Colvin, New York

Member of the Society

The advantages of standardization of parts which are or may be used together are becoming more and more apparent in all manufacturing and are now being considered by builders of such machines as lathes, planers, milling machines, etc. The question is how far can this be carried, for if carried too far, it might become a detriment rather than a help.

The builders of milling machines decided some years ago upon a standard of capacity, so that a buyer knows that a No. 2 miller of nearly all standard makes, has a table movement of 28 in. by 8 in. This does not, however, say how much power each machine has nor specify its size of spindle or similar parts.

Lathe and planer builders give nominal sizes in inches and feet, but there is no way of knowing from a list of a 14-in. lathe whether it swings 15 or 16 in., or whether a 36 in. by 36 in. planer will take in 37 or 38 in. between housings and under the rail. One effect of this is to allow a lathe that will actually swing 16 in. to be listed as and sold for the price of a 14 in. without the odium of cutting price. Some over size allowance must, of course, be made, but the general opinion seems to place this at not over 1 in., so that a 14-in. lathe will swing over 14 but not over 15 in., with the same allowance on planers and other machines.

After standardizing the work-holding capacity of machines, the question of what parts can be standardized to advantage must be considered. How far is it desirable to go, even were standardization not an extremely difficult proposition, and is it desirable to standardize any parts which are not used interchangeably in the modern shop? Assuming that these are the only parts to standardize, which parts are they?

Slots which are used to hold fixtures, as in milling machine tables and in planers, fall easily in the list of desirable parts to be standardized and this might easily be extended to lathe carriages, boring mills and other machines to which fixtures are attached. The adopting of a few sizes of T-slots and the apportioning of a definite size to certain sizes of milling machines, would enable fixtures to be transferred from one make of machine to another of the same size. Should it happen to be desirable to use this attachment on a large miller or on a planer or boring mill it might be necessary to use adapters. These, however, could also be standard. Definite T-slots could be assigned to 36-in. and other sizes of boring mills, etc., these being determined by the experience of the user as well as the maker. The exact size, however, is not of so much importance as the fact that they be standardized.

Standard bolt and cap-screw head sizes are a great convenience. The machine with a single wrench to fit all bolts, tool block, carriage stops, etc., is not often impossible, if it be made double ended, and while it may not be advisable to limit design by standardizing the size of bolts on a 16-in. lathe, there are probably many cases where they might be interchangeable without detriment. Beyond this, the problem becomes increasingly difficult.

There are some who advocate the standardization of lathe spindles, bearings and noses, but this seems to be treading on dangerous ground as well as being of doubtful utility. While there may be cases where it is convenient to be able to interchange chucks and face plates, these are few and far between in modern manufacturing. It may be a convenience in the jobbing shop, but it is seldom used elsewhere, and is not to be considered where accurate work is to be done. Those who have tried know that it is impossible to secure really accurate work unless a piece is finished at one setting of the chuck, in many cases a special chucking plate or seat being turned out whenever a new lot is to be done.

Light work does not require a heavy lathe nor will it stand the heavy cuts of which the modern lathe is possible, so that unless we have standards for light and heavy lathes, it would be a hardship rather than a benefit. The sizes of spindles and bearings should be left to the designer and the buyer can select whatever he needs.

After we have considered the standardization of parts we can well spend a few moments on the question of names of machines and parts, especially the latter, for while many of us believe that the present naming of many of our machines is crude if not incorrect, there is little confusion caused by mistaking the kind of machine which may be meant, either in conversation or in writing. But when it comes to parts of machines, it is a very different story. Nearly every maker and user knows of exasperating delays in supplying and securing parts of machines owing to a lack of uniformity in names. This often necessitates the writing of several

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letters, and with machines standing idle the cost of delays mounts up into large figures during a year.

Many manufacturers supply a list of parts of their machines and in most cases illustrate the part itself so that there can be little difficulty in distinguishing it. Unfortunately, however, few shops keep these lists where they are handy, and when it becomes necessary to send for a repair part they designate it by the terms used in that locality for similar pieces, as is very natural.

A little attention in the naming of machine parts would obviate much of this difficulty. It is a process of education, and if we will begin by naming parts according to the service they perform, much difficulty can be eliminated. This is already done to a considerable extent, as in the use of such terms as "lead" screw, "feed" rod, and similar names. Such names, however, as "cat head," "tumbler gear," "planer harp," etc., form a separate language which must be learned the same as Sanskrit or Esperanto.

Another example of confusion in this way is the naming of the handles by which a turret slide is advanced to the work. This is commonly known as a pilot wheel on account of its resemblance to the wheel used by a pilot in controlling the course of his vessel. In some parts of the country, however, it is known as a "turn-stile" and a "spider," although the latter name has a very different meaning to most of us.

If we could devise some means of designating the machine parts by the work they perform without having the names too cumbersome, it would seem as though the matter might be simplified, and at the present time, this appears to be more important than the naming of the machines themselves, however badly they may be in need of a more rational designation.

Another field of standardization that promises important benefits to the user is that of the electric motors designed to be applied to machines. At present, there is no uniformity in speeds, powers and general dimensions. Thus it is practically impossible to design the details for attaching a motor to a machine until the precise specifications of the particular motor to be used are obtained from the motor builder. A great benefit would be conferred upon all motor users if the following points could be standardized: the voltage and speed for direct-current motors from, say ½ to 50 h.p., the voltage, cycles and speeds for alternating-current motors for the same range of power, the outline of the feet with the location of bolt holes, the diameter of the armature shaft, size of keyway and distance from shaft shoulder to center of figure of motor, the distance from the center of the shaft to the bottom of the feet, and the general clearance dimensions for the outside of the motor. In 1910 these details and others were considered by a committee of the National Machine Tool Builders' Association, coöperating with a similar committee of the Association of American Motor Manufacturers. A number of features were recommended, but these have not been put into effect. Meanwhile, motor users are subjected to annoying delays and difficulties in applying motors to machines.

It must not be thought that the standardization of machine details is a difficult matter. It is much more difficult in theory and in consideration than in adoption and application. Some ten years ago, the United Shoe Machinery Company established a department to standardize details of the 250 or more machines that they built at that time. The machines under consideration had been built over a period of 36 or 40 years by a large number of different designers in many different shops. Thus uniformity did not exist there. In fact, it is safe to say that there was less uniformity in regard to general details of these machines than will be found among the details of machines of the same general class built to-day by representative manufacturers. For a generation, shoe machinery had been leased on royalty to the shoe manufacturer, and the machinery building company was under obligation to furnish spare parts. Thus, changes in detail of necessity might interfere seriously with a well-established business. However, the advantages for standardization were so great, that the possible disadvantages were overweighed and the work started. It was carried through to completion during a period of about a year, and, although at first some little confusion and difficulty occurred in furnishing spare parts to old machines, these difficulties rapidly disappeared and the advantages of uniformity became apparent.

Standardization must never be undertaken in a weak-kneed fashion. It must be approached courageously, with the exercise of good judgment, but an appreciation that difficulties, if they arise, will be only temporary in character. It is far better to have some difficulty for a year or two than to hamper the use and applications of machines for a generation. Even though it is impractical to change the details on existing machines that have been on the market for some time, the newer details can be employed in fresh designs, which are constantly being brought out. After the lapse of a few years, the old order of things has disappeared and the new is firmly installed with its attendant advantages. The attitude should be one of attack when such a problem is presented, attack with the determination of finding one detail and making that uniform, instead of giving prolonged consideration to the possible difficulties and disadvantages.

DISCUSSION

Luther D. Burlingame (written). I agree with the spirit of this paper as to the matter of standardization, for one reason, because it takes a conservative position that will not hamper and be a check to improvements in machine designing. I believe that the standardization of work-holding capacity is desirable and feasible, and would be an entering wedge where there could be standardization without any question of blocking progress.

This could be followed by the standardization of work-holding means, another step where it would seem that some practical progress can be made.

I am pleased to see emphasis put on the standardization of motors because, while it may seem like asking "the other fellow" to do the standardizing, it is very important, from the machine builders' standpoint, that motors should be brought to some uniformity, especially in the provision for attaching to machines.

Referring to the standardization of bolts, nuts, and other holding parts that must be adjusted by the wrenches, it seems from my own experience more important to standardize the wrenches, having as few sizes as possible on a given machine, even where to do so means special bolts and nuts.

I am also interested in the emphasis that is placed on the matter of naming the parts, because that is a matter at present causing constant trouble, often requiring extended correspondence to find out what is meant. It would help to bring about uniformity if we had an up-to-date mechanical dictionary. The fact that national organizations are taking this matter up is encouraging, as promising results for the future. Our mechanical press has done much along this line in gathering information as to names used and in bringing about the use of uniform terms.

F. DeR. Furman commended the paper from the educational point of view. The many names for the same fittings used in different sections of the country and such odd and peculiar names as those cited by the author, "cat head," "tumbler gear," etc., which are almost meaningless to the student, all help to block progress by increasing the amount of material to be taught and explained. Fixed names to designate fixed parts would help in the advancement of educational work.

A. B. Carhart (written). The dark ages when each manufacturer wilfully chose special threads, special connections and special dimensions, are passing. The tendency is now to meet upon common ground so that the purchaser may freely determine the relative merits of the different products offered.

The suggestions in the two concluding paragraphs of the paper have undoubtedly appealed to everyone engaged in manufacture. Almost every month in the year some piece of apparatus is brought up for review to weigh the advantages and disadvantages involved in a proposition to change or to standardize. If it is only a question of nomenclature, it can often be settled in the drafting room or by the engineering staff. I think Mr. Colvin is especially helpful when he suggests, at the close of his paper, that there should be greater courage in such matters, and that we should avoid giving too long consideration to the difficulties and the disadvantages in changes that may seem to be worth while.

The inclination to name parts by the work they perform is a commendable one, and should be extended further than we have done in this country, so long as we do not fall into the temptation of using words such as some of the compound German names. I think the greatest influence toward such reform lies with the trade papers. Their example will assist much in any improvement in this direction, and undoubtedly their influence, in correct usage, is greater than ever before in the history of machine tool building.

Fred J. Miller (written). Little can be done toward obtaining standardization of machine construction unless we give to the makers of such machines a commercial incentive to adopt standards. If we merely read papers and discuss the desirability and general loveliness of having standards, we shall never bring about their adoption. We must recommend standards by some authority, so that such standards can be known to exist, and so that a designer or producer of any kind of machinery who is considering a dimension that will affect, either by connection with other machines, or in any other way, the matter of standards, can refer to a definite standard that has been established; otherwise he may make it just enough different to constitute an addition of a new variety that could as well have been avoided.

The Society has a committee on Engineering Standards which has been in existence for some time. I do not remember how it is constituted, but it seems very desirable that the members of this committee should be chosen with a view to their acquaintance with the various lines of machines, such as engines, motors, machine tools, etc. Then if each member of the committee studies carefully the points pertaining to his field and their connection with those in other fields, and then, where possible, the whole committee recommends a standard for such things as a standard may be applicable to, it may lead to good results.

That method will not in most cases result in immediate conformation to such standards, because the various builders will have their drawings, patterns, catalogues, etc., and the new standard may not come into use except as newly designed machines may be brought out.

We have had an interesting experience in the Remington Typewriter Company. We have four factories each making one or more different typewriters. We found that no attention had been paid to the reduction of the variety of screws made for these machines. About 25 to 35 taps were used for each machine, each tap differing in size, in pitch, or in both, from any other, and no two factories used the same form of thread. A committee was appointed to study the matter and it found that the commercial incentive, to which I have referred, did not exist for making any change in the machines already on the market, screws for which were in our branch offices all over the world, and stocks of the same screws and tools, and gages for producing them, in the factories. The investigation did lead to a different practice with the newer models, however. When a new machine was put on the market about a year ago or over (sold exclusively in Europe) only seven taps were used in the entire machine, instead of 35; the seven answered every purpose, and of course, there is a very great advantage from the manufacturing as well as from the repairing standpoint—it simplified the whole matter.

When we came to make still another new model, in another factory, we asked that they confine themselves not only to the list which our committee had prepared, but that they confine the screws to be put in the new machine to screws that were already included in the machine we had previously made, and that had been on the market for a year or so. They found they could easily do that, and used only four different taps in that entire machine. These screws conform to a certain portion of the list recommended by the committee appointed by the society to recommend standards for machine screws.

That is an example of working the thing out where a num-

ber of factories are under one ownership and control. There is, of course, no such control that can be exercised in the general field, but a committee such as we have acting for this Society can at least define standards, and call attention to them in a way such that when a man is doing a new thing, and it is a question of whether he will conform to the standard or do something else, he will generally prefer to conform to the standard. In that way we shall accomplish something along the line of standardization.

James Green. There is one point with respect to standardization that would greatly help the operator of the machine. That is the direction of motion of the handles for adjusting parts. On one machine the operator turns the handle and a spindle will go down; on another similar machine he will turn a handle in the same way and a spindle will go up, which is confusing to him. Another point is with regard to special heads for screws. It is the practice of one manufacturer to use the same size heads on screws of different diameters in so far as it is practicable to do so, so that the same wrench may be used on different screws and on various machines.

Gilbert S. Walker said he had written a good many Government specifications and had a rule that seemed to work pretty well in practice. He tried to word the specifications so as to let in the regular products of three good manufacturers and to keep out as many of the others as he could. The reason for three was that the regulations require the securing of at least three bids. When there were too many bids good articles were less likely to be obtained.

D. M. Wright[1] considered the standardization of mechanical nomenclature to be closely allied to the matter of standardizing machinery, and thought that an investigation of the work of the nomenclature committee of the National Machine Tool Builders' Association in this direction might suggest to the Society the formation of a similar committee. The Nomenclature Committee of the National Machine Tool Builders' Association would be glad to co-operate with the Society if this were done. A comparison of the various mechanical magazines of today with those of five years ago will show that practically all of them have very materially changed their index and their editorial language, and that a large number of the advertizers have also changed their advertisements to use the preferred nomenclature. The manner of changing seems so simple and results in so much good it is hoped that the Society will look favorably upon the formation of a Nomenclature Committee.

The Author. It is gratifying to note the tendency toward standardization as shown by the discussion of the various points brought out. The suggestion of Mr. Miller, that we must give a commercial incentive toward the adoption of standards, is particularly helpful. As he points out, we can hardly expect to affect the design of machine already on the market, but a little consideration would do much toward standardizing new products.

The commercial incentive can best be supplied by the consumer asking or even demanding products which embody such standard dimensions as may be considered good practice and recommended by the Society or others. When enough consumers in ordering machine screws, for example, specify A.S.M.E. standard, screws of this kind will be carried in stock by all dealers.

[1] Secy. and Treas., The Henry & Wright Mfg. Co., Hartford, Conn.

REPORTS OF COMMITTEES

STANDARD SIZES OF CATALOGUES

The Committee has made an extensive investigation of the various sizes of catalogues in common use, and has had correspondence with many paper manufacturers, printers, advertising agents and makers of filing boxes and cabinets, as well as with manufacturers of machinery and supplies. The general conclusions it has reached may be summarized as follows:

a There is a universal opinion that catalogue sizes should be standardized. It is not necessary to give any reasons here for this opinion, as it is all on one side.

b The standard of 6 in. by 9 in. has for so many years met with such wide acceptance, probably two-thirds of all the catalogues that are now made being either that size, trimmed as closely to exact size as possible, or within ¼ in. of it in one or both dimensions, that it may be considered as too well established ever to be abolished.

c The 6 in. by 9 in. size is too small for many purposes, and it is necessary to have for some purposes a size which is about 8 in. by 10½ in. or 8½ in. by 11 in.

There are objections to having both considered as standard sizes, and as there is an increasing tendency to the use of the larger size the Committee recommends that 8½ in. by 11 in. be the standard. Electrotypes 4 in. by 7 in., which are commonly used for 6 in. by 9 in. pages, may conveniently be used, two on a page, on an 8½ in. by 11 in. page, but they are too large for the 8 in. by 10½ in. page.

The 8½ in. by 11 in. page folded twice makes 3⅞ in. by 8½ in., which is a convenient size for a long folder.

d The 9 in. by 12 in. size has been adopted by a few for very large catalogues. While it is generally acceptable for technical and trade journals, it is rather too large for a catalogue, unless it is to be a large cloth-bound book, to be placed on a shelf and not filed in a cabinet. It should, therefore, not be recommended as a standard for common use.

The following extracts from some of the letters received show the variety of opinions that exist as regards the sizes that should be adopted:

Matthews-Northrup Works, Buffalo, N. Y. Paper stock is made in sheet sizes 25 in. by 38 in. Since cuts have been made and tabular pages set for years to fit 6 in. by 9 in. it should prove very expensive for many firms to change. An opportunity is afforded by the 9 in. by 12 in. size to run the text descriptive matter or tabular panel of sizes and prices immediately under the illustrations on the same page. The 8½ in. by 11 in. size works out in good proportions. These three sizes seem to be the only ones that need be planned for.

Robert L. Stillman, New York. I suppose there are more catalogues made 6⅛ in. by 9¼ in. or 9⅜ in. by 12¼ in. than any other size, because they both cut from 25 in. by 38 in. paper which is of standard size, allowing ⅛ in. for trim.

The 33 in. by 46 in. size would make 8⅛ in. by 11¼ in. It might be reduced to 11 in. to get it within the standard letter size.

Ticonderoga Pulp & Paper Co., New York. It would be much to the advantage of every one if all catalogues could be standardized to a certain size. It would be a great assistance not only to the paper manufacturer but also to the dealer and printer, as in that case the dealer could carry in stock standard sizes and could supply paper promptly, and printers would not then have to wait for paper to be made especially.

Frank Presbrey Co., New York. Sent samples 6¾ in. by 9¾ in., and recommended it as the size used in all standard magazines. In reference to letter size, 8½ in. by 11 in., if a movement be inaugurated which will result in making up to this size all catalogues and monthly bulletins a great deal will be accomplished.

Collin Armstrong Advertising Co., New York. As far as our experience goes 5½ in. by 8 in. is the most convenient size. Anything near 8½ in. by 11 in. would in our opinion be too large to be handled easily, would be apt to go to pieces quickly and probably not be kept carefully by the recipient, as would be the case with a smaller book.

F. F. Coleman, Publicity Manager, Lidgerwood Mfg. Co., New York. All publications except catalogues intended for filing should be eliminated from consideration. The best size for catalogues is 9 in. by 12 in. upright. Personally, I would abolish the 6 in. by 9 in. size.

J. Horace McFarland, Harrisburg, Pa. In the nursery trade the 6 in. by 9 in. size does not permit such attractive illustrations in an economical manner as the growing vigor of selling campaigns required, and there is a great disposition to get away from anything of a standard size and to make the catalogue different.

Hammacher, Schlemmer & Co., New York, are working on a new edition of their catalogue which will be 9 in. by 12 in. For a number of years they used 5½ in. by 7¾ in., but it is too small for a book of say 1200 pages. For pamphlets and smaller sizes will use 6 in. by 9 in.

Manning, Maxwell & Moore, New York. Books for general mechanical goods, both small and large should be 6 in. by 9 in. wherever it is practicable. In many cases a larger sheet is necessary to take the proper size cut to show important small details.

General Electric Company, Schenectady, N. Y. We use and recommend 8 in. by 10½ in. catalogues as standard. The width of page is valuable for displaying illustrations and tabular matter. Our standard letter paper is 8 in. by 10½ in. Our standard photographic plate is 8 in. by 10 in.

The Yale & Towne Mfg. Co., New York. C. L. Redfield, Adv. Mgr.—Printed matter may well be any of the following

Presented at the Spring Meeting, Baltimore, 1913, of The American Society of Mechanical Engineers, 29 West 39th Street, New York.

sizes for reasons given: 6 in. by 3⅜ in. for folders, because this size just fits the small Government envelope which is still very largely in use among business people; 8 in. by 3½ in. for folders and small booklets, because it just fits the No. 9 Government 2-cent envelope and makes it very easy to use such printed matter to accompany correspondence; 6 in. by 9 in. for small catalogues, as we have been led to believe that this is more acceptable to the machinery and other trades; 8 in. by 10½ in. for sheets which accompany correspondence, as this is the size of our letter head; 9 in. by 12 in. for our more important catalogues, this being the accepted size with the paper makers and is carried in stock.

From a *Circular of Advice* issued by the American Institute of Architects, April 1913, manufacturers are earnestly urged to adopt a standard size of 8½ in. by 11 in. for all catalogue matter which they desire an architect to keep for reference, this being the size which can be most readily filed in the standard letter files of the day. For convenience in indexing, it is essential that all catalogue matter should be divided into sections, so that the sections of different manufacturers treating on the same subject may be grouped together. This means that only one article should be treated on a single leaf, and that no leaves should be bound together except where they refer to a single article or variations of that article.

A list of 927 catalogues measured for the Technical Publicity Association showed that there were no less than 147 different sizes. Dividing the 147 sizes into eight groups there are the following:

3 to 3¾ by 5 to 9, sixty of which 34 are 3½ by 6.
4 to 4¾ by 5¾ to 9¼, one hundred and twenty of which 21 are 4 by 6 and 26 are 4 by 7½.
5 to 5¾ by 6½ to 9¼, one hundred and eighteen of which 15 are 5 by 7 and 17 are 5 by 7½.
6 to 6¾ by 7 to 10½, four hundred and forty three of which 325 are 6 by 9 and 23 are 6½ by 9½.
7 to 7¾ by 7 to 11, eighty-three of which 20 are 7 by 9 and 17 are 7 by 10.
8 to 8¾ by 9½ to 12, sixty-four of which 15 are 8 by 10½ to 11, and 16 are 8½ by 10½ to 11½.
9 to 9¾ by 10¼ to 12½, thirty-three of which 17 are 9 by 12.
10 to 11 by 11 to 14½, six.

The first four groups contain 80 per cent, and the last four groups only 20 per cent of the whole number of catalogues.

RECOMMENDED SIZES

	Inches
Index card, standard	3x5
Index card, larger sizes	4x6 and 5x8
Folders:	
Small	3⅜x6
Large	3¾x8½
Catalogues, standard size	6x9
Bulletins and large catalogues, standard	8½x11

In addition to the recommendation as to sizes the Committee would also recommend the following:

a For paper covered catalogues intended to be permanently filed, the edges, including the cover, should be trimmed to exact size. No fancy deckled edge or dark tinted paper should be used.

b Overlapping edges of the cover are permitted when the catalogue is bound in covers stiff enough to support its weight in boards or heavy card paper.

c The title should always be printed on the exposed back of the catalogue whenever possible, for the purposes of identification. When the book or catalogue stands on its lower edge the title should be read from the top downwards, as in Fig. 1.

d Every catalogue should have a date on its title page.

e A standard size index card 3 in. by 5 in. should be enclosed in each catalogue, with the title of the book and a brief statement of the character of its contents printed on it.

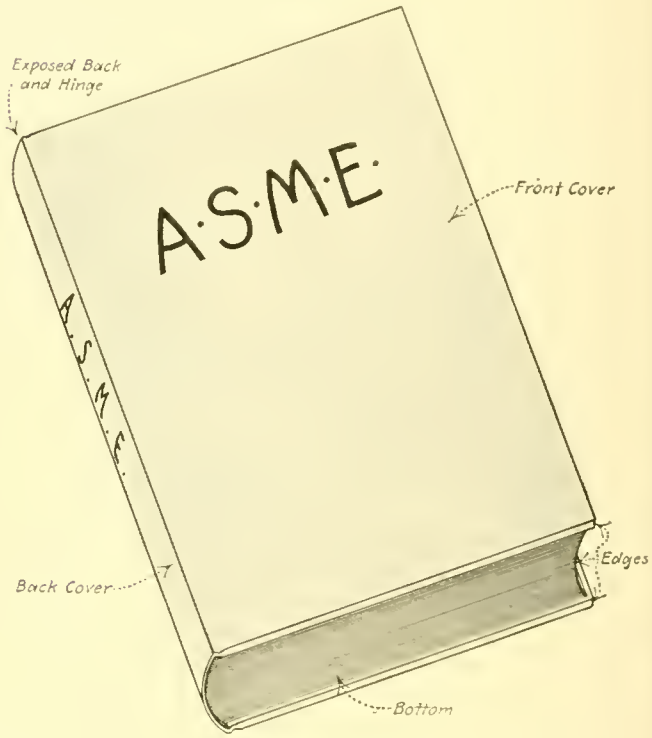

Fig. 1 Showing Arrangement of Title on Back of Book

Catalogues, extra large, and technical press	9x12
Transactions of societies, pamphlets, etc	6x9

PAPER BOXES, DRAWERS AND VERTICAL FILING CABINETS

(Inside Measurements)

For 6 in. by 9 in. catalogues, pamphlets and 9 in. by 12 in. papers folded once	6½x 9¾
Paper boxes and drawers for larger sizes	9½x12⅛
Vertical files for large sizes	10x12⅛

Fig. 2, which gives a clear idea of the relation of these several sizes to each other is drawn to scale, showing them superposed.

FILING BOXES AND CABINETS

Jesse Jones Paper Box Co., Philadelphia, Pa. A box that will hold a sheet 8½ in. by 11 in. is by far the most in demand.

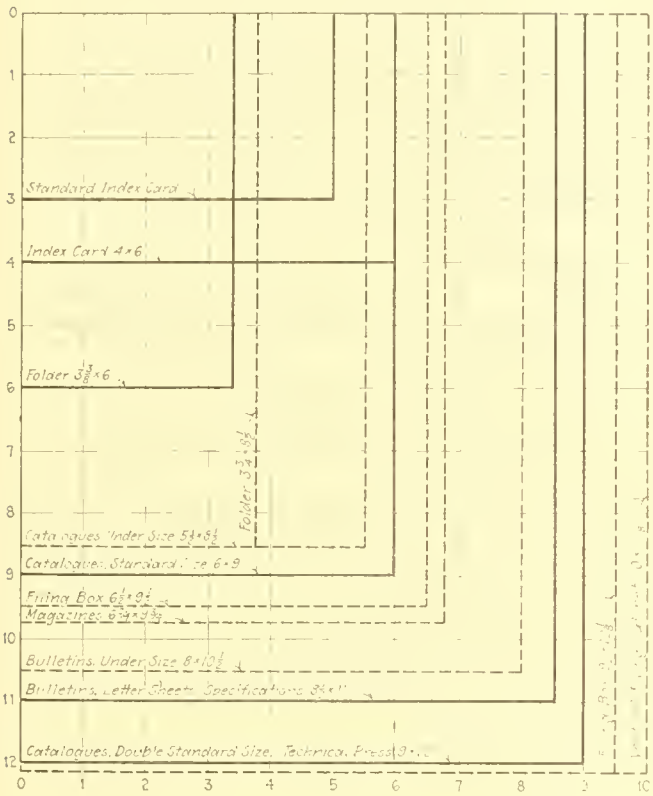

FIG. 2 RELATION OF CATALOGUE SIZES

Various makers of filing cabinets give the following sizes, in inches, of drawers (inside measurements):

Correspondence files, 9⅞ by 11 9/16, 10 by 12, 10½ by 12⅛, 10 7/16 by 12.

Legal cap files, 9⅞ by 14⅜, 9½ by 15, 10½ by 15¼.

Invoice files, 7½ by 9½, 7¾ by 9¾, 8 by 10, 8¼ by 10 1/16.

The 9⅞ in. by 11 9/16 in. is too short to take a 9 in. by 12 in. paper. There seems to be no reason for making the height more than 10 in. as no letter paper is over 8½ in. wide. A size of 10 in. high by 12⅛ in. wide would seem to be the best for all large-size catalogues. It would hold two 6 in. by 9 in. side by side, although the filing of 6 in. by 9 in and 9 in. by 12 in. papers, together in the same drawer is objectionable, as the smaller sized papers have a tendency to lap over on each other and thus to occupy more space than they should. The extra inch in height gives ample room for division cards and tabs. The legal cap and the invoice files are not suitable for any of the standard sizes of catalogues.

A size suitable for the 6 in. by 9 in. catalogue does not appear to be in the market. If one were made with drawers about 6½ in. by 9¾ in. it should have a ready sale. The drawer would be more easily handled than the 10 in. by 12⅛ in. size.

Respectfully submitted,

WM. KENT, *Chairman*
J. R. BIBBINS
M. L. COOKE
W. B. SNOW
} *Committee on Standardization of Catalogues*

October 25, 1913.

STANDARDIZATION OF PIPE THREAD GAGES

The purpose of the Committee on Standardization of Pipe Threads has been to fix manufacturing limits for the use of the Briggs standard pipe thread gages when tapping fittings or flanges, so that pipe cut to the Briggs standard might always enter a definite number of turns. Although the Briggs standard is used almost universally for pipe threads in the United States, the method of its use for female threads has not been established, in that no determinations have ever been made of the standard depths to which hand plug gages should enter. This has resulted in much confusion in the past, inasmuch as pipe threaded to the Briggs standard is liable to vary in the number of threads it would screw into fittings tapped at different shops. This tendency is so marked that pipe fitting is handled in practically all cases by sending the flanges to the shop where the pipe is being cut, in order to be sure of satisfactory results.

This matter is conceded to be a simple one in that all it requires is an agreement among the manufacturers of fittings as to the point at which a ring should be attached to the gage, to establish, when the gage is inserted by hand, the proper depth of the thread. To this end the committee has met in conference with representatives of the manufacturers and also of the committee of the Society on International Standards for Pipe Threads. C. A. Olson, Chairman of the Manufacturers' sub-committee on Pipe Thread Gages, stated at this meeting that his committee had made a study of present practice among the various manufacturers and had adopted tentative definitions of the gages to be used, of the proposed thickness of ring gages acceptable to the manufacturers, and of the tolerances to be allowed. These he submitted as follows:

The gages shall consist of one plug and one ring gage of each size.

The plug gage shall be the Briggs standard pipe thread as adopted by the manufacturers of pipe fittings and valves, and recommended by The American Society of Mechanical

Presented at the Annual Meeting 1913, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Engineers in 1886. The plug is to have a flat or notch indicating the distance that the plug shall enter the ring by hand.

The ring gage is to be known as the American Briggs standard adopted by the Manufacturers' Standardization Committee in 1913, and recommended by The American Society of Mechanical Engineers, the Committee on International Standard for Pipe Threads, and the Pratt & Whitney Company, manufacturers of gages. The thickness of the ring is given in the following table. It shall be flush with the small end of the plug. This will locate the flat notch on the plug flush with the large side of the ring.

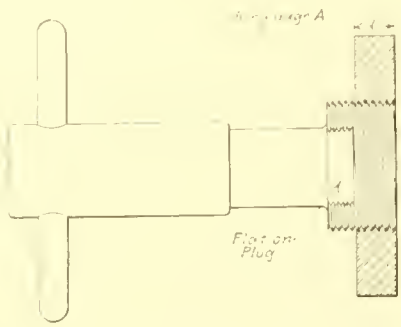

Fig. 1 View of Plug and Ring Gage

Pipe Size	Adopted Thickness of Ring Gage *A*
⅛	0.1801
¼	0.200
⅜	0.240
½	0.320
¾	0.339
1	0.400
1¼	0.420
1½	0.420
2	0.436
2½	0.682
3	0.766
3½	0.821
4	0.844
4½	0.875
5	0.937
6	0.958
7	1.000
8	1.063
9	1.130
10	1.210
12	1.360
14	1.562
15	1.687
16	1.812
18	2.000
20	2.125
22	2.250
24	2.375

REMARKS

The table above indicates the dimensions of the ring gage *A* shown in Fig. 1, which are the figures adopted by the Manufacturers' Standardization Committee.

In the use of the plug gage shown in Fig. 1, the notch on the plug is to gage, and one thread large or one thread small must be the inspection limits.

In the use of the ring gage, male threads are to gage when flush with small end of ring, and one thread large or one thread small must be inspection limits.

After consideration of the matter by the entire committee, it was voted that the table of sizes and tolerances submitted be approved as above, by the joint committee, and that there be deposited with the Bureau of Standards at Washington, D. C., a set of gages to be known as the American Briggs Standard for Pipe Threads, the expense of the manufacture of these gages to be provided for at a conference between the Manufacturers' Committee, the Bureau of Standards, and the Pratt & Whitney Company.

Respectfully submitted,

E. D. Meier, *Chairman*
George M. Bond
A. M. Houser
J. C. Meloon
Charles A. Olson
Peter C. Patterson
Henry G. Stott

Committee on the Standardization of Pipe Thread Gages

STANDARD THREADS FOR HOSE COUPLINGS

REPORT OF SUB-COMMITTEE ON FIRE PROTECTION

In considering the problem of the adoption of a hose coupling thread, it became a question whether to advise specifications which would show the extreme of mechanical strength without reference to the preponderance of designs of a less theoretical value in general use, or to seek for the introduction of a threaded coupling, the characteristics of which would most closely accord with the majority class, and at the same time prove to be an intermediary of such capacity as to accommodate itself to interchange with a large proportion of couplings not exactly conforming to its dimensions.

Accepting the latter method of procedure as promising the widest measure of success, a committee of the National Fire Protection Association undertook a special investigation of existing conditions, using the report of a special committee under C. A. Landy, chairman, in 1891, as a basis. After securing additional data they became convinced of the practical value of the specifications named in that report, and submitted as a standard coupling for 2½-in. hose, one showing a diameter of 3 1/16 in. over male end thread with 7½ threads to the inch, by the use of which it was practically demonstrated that couplings ranging in outside diameter from 3 1/32 in. to 3 5/64 in., with either 7, 7½ or 8 threads to the inch, could be so modified as to couple-up in service with this suggested standard, and thus render over 70 per cent of the 2½-in. couplings known to be in use, conformable

Presented at the Annual Meeting 1913, of The American Society of Mechanical Engineers.

to the proposed standard at small expense as to time, money or labor.

In elucidation of the essential features of this standard it was deemed wise to formulate specifications covering 2½, 3, 3½ and 4½-in. hose couplings, the inside diameters of which were to be in conformity with the sizes named, specific details relating to each of the standard sizes being shown in the printed specifications as follows:

SPECIFICATIONS FOR HOSE COUPLINGS

Inside diameter of hose, inches	2½	3	3½	4½
Number of threads per inch	7½	6	6	4
Male Couplings				
Outside diameter of thread *finished*, inches	3 1/16	3⅝	4¼	5¾
Diameter at root of thread, inches	2.8715	3.3763	4.0013	5.3970
Clearance between male and female threads, inch.	0.03	0.03	0.03	0.05
Total length of threaded male end, inches	1	1⅛	1⅛	1⅜

The above are to be of the 60-deg. V-thread pattern with 0.01 in. cut off the top of thread and 0.01 in. left in the bottom of the valley in 2½-in., 3-in. and 3½-in. couplings, and 0.02 in. in like manner for the 4½-in. couplings and with ¼-in. blank end on male part of coupling in each case. Female ends are to be cut ⅛ in. shorter for endwise clearance, and they should also be bored out 0.03 in. larger in the 2½ in., 3 in. and 3½ in. sizes, and 0.05 in. larger in the 4½ in. size in order to make up easily and without jamming or sticking.

SUGGESTIONS FOR CONVERTING NON-STANDARD COUPLINGS FOR SERVICEABLE INTERCHANGE WITH THE NATIONAL STANDARD

The fact that the National Standard has received the unqualified approval of all the leading organizations concerned with water supplies and fire departments, forms a strong argument for its early adoption in all localities. In order to demonstrate that the question of expense in changing over to the standard is less serious than is often imagined, the following suggestions, contemplating a gradual change from non-standard to full standard equipment, are submitted in the belief that the comparatively light cost of such a procedure should not delay so important and beneficial an improvement in any town or city. These suggestions are intended to apply to the period of transition which must of necessity precede complete standardization.

Considering first the 2½-in. hose couplings and hydrant outlets in general use, we suggest that:

a Contracts for new hydrants should specify that the nipples be equipped with the National Standard Hose thread.

b Existing hydrant nipples should be replaced by standard nipples. This may readily be accomplished at comparatively small expense through the use of a special device or tool now on the market; or as a less satisfactory method, the nipples may be equipped with adapters having standard thread on the outboard end. These adapters should be fastened in position so as not to be readily removable.

c Fire engine nipples should be provided with adapters having standard thread on the outboard end. These should be secured in place so as not to be readily removable.

d In many cities and towns where the 2½-in. hose couplings, as well as the nipples on

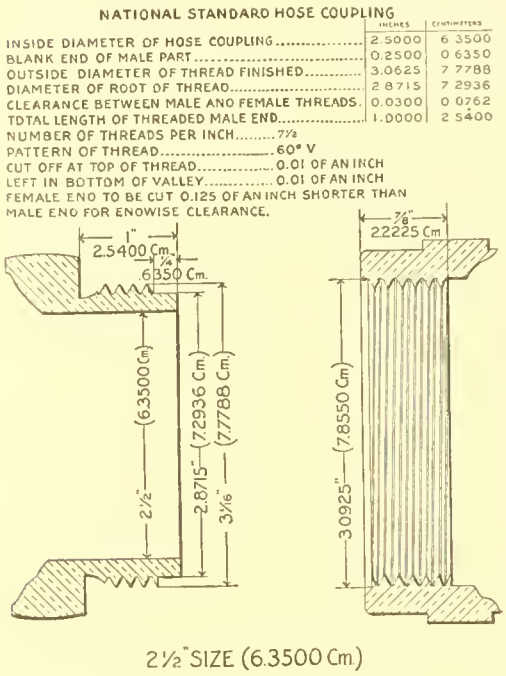

FIG. 1 DETAILS OF 2½-IN. COUPLING

hydrants and fire engine outlets, show 7, 7½ or 8 threads to the inch, wide variations occur in outside diameter over the thread of the male end of the couplings. If such variation does not exceed 1/32 in. below 3 1/16 in. (equaling 3 1/32 in.), or if the variation does not exceed 1/64 in. in excess of 3 1/16 in. (equaling 3 5/64 in.), it becomes feasible to render both male and female couplings adaptable for interchange with the Standard 2½-in. hose couplings (measuring 3 1/16 in. outside diameter on the male end and 7½ threads to the inch) by the use of an adjustable tap for the female end of the coupling, or an adjustable die for the male end of the

coupling, either tap or die having the same number of threads to the inch as the coupling or nipple to be treated.

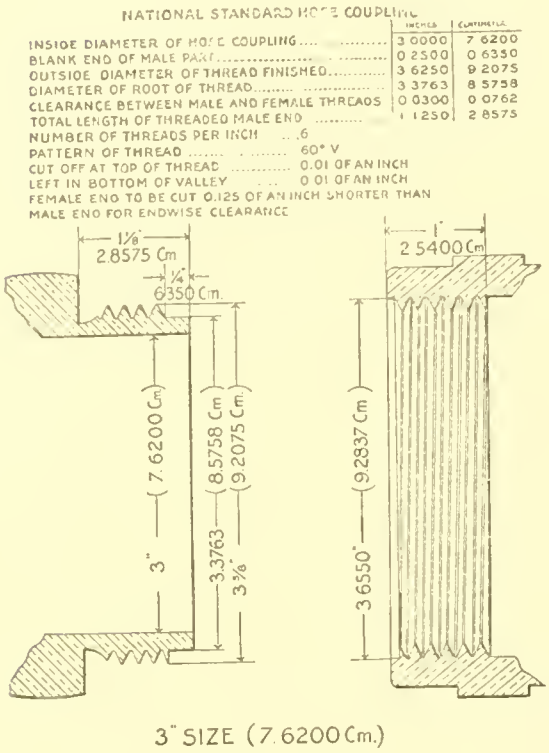

Fig. 2 Details of 3-In. Coupling

Any deviation within the limits named may readily and cheaply be overcome without the removal of couplings from the hose or of the nipples from the hydrant or engine. It may be well to emphasize the fact that in adapting the 7 and 8 thread coupling to interchange with the National Standard of 7½ threads, it is thus intended to provide an interim measure to serve until the standard has been fully installed, the reduced coupling being discarded as the hose wears out, and all new hose purchased to be fitted with the Standard couplings, thus securing a gradual and inexpensive method of standardizing the whole equipment of the city.

e Couplings of new hose, whenever purchased, should be the National Standard, and specifications under which new hose is purchased should always include a clause to this effect.

f Until all hose on hand has been provided with standard couplings or has been converted as suggested on the preceding page, a sufficient number of adapters should be carried on each hose wagon, so that the unconverted hose can be coupled up with the standard outlets of hydrants or fire engines.

g In view of the fact that 3-in. hose is coming into more general use, it is deemed advisable that such hose should be fitted with 2½-in. couplings having threads which conform to those on 2½-in. hose already in use.

It is believed that the total expense involved in a complete change from existing to standard conditions will not exceed the cost of the operations described in *b*, *c* and *f*, and that no further steps will be needed in any city save to order all new equipment of every description to be supplied with National Standard threads.

It is of course clear that a similar line of action, as noted in *a*, *b*, *c*, *e* and *f*, should be followed in the case of the couplings and hydrant outlets pertaining to the suction hose of the engines. While the cost will be

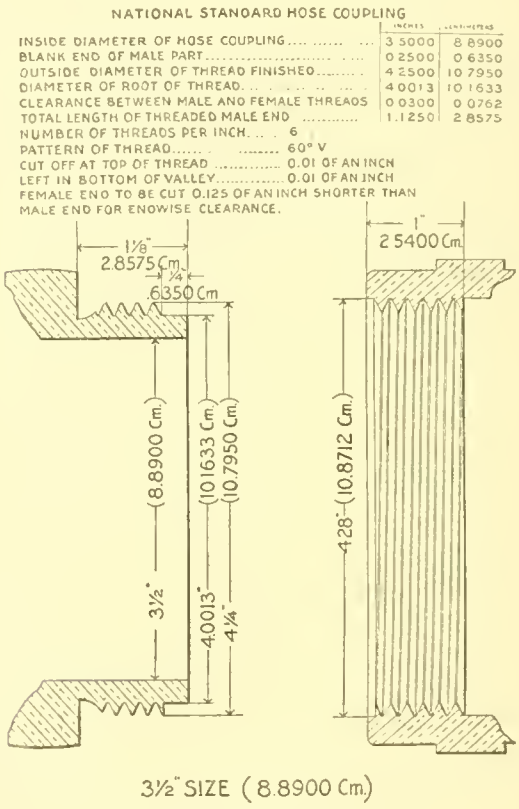

Fig. 3 Details of 3½-In. Coupling

greater per outlet, the outlets to be thus equipped will be much less in number than for the 2½-in. connections.

While the extremes of diameter in couplings as herein indicated appeal to this committee as being conservatively reliable for the treatment recommended, many instances of adaptation have been recorded wherein the deviations treated range as low as 3 in.

and as high as 3 3/32 in. with satisfactory results in service, thus strongly emphasizing the value of the "National Standard" as an intermediary or accommodation thread coupling of wide adaptability.

It is recommended that the Higbee style of cutting the thread be adopted hereafter in order to facilitate speed in coupling up and in avoiding crossing.

These specifications, covering the essential features for hose couplings and hydrant fittings for public fire service, have been agreed upon in joint conference with accredited representatives of a number of organizations and associations interested in or controlling this class of work. They will be known as the National Standard, and to date have been adopted by the following associations:

American Public Works Association, American Society of Municipal Improvements, American Waterworks Association, International Association of Fire Engineers, League of American Municipalities, Minnesota State Firemen's Association, National Board of Fire Underwriters, National Fire Protection Association, National Firemen's Association, New England Waterworks Association, North Carolina State Firemen's Association, Pennsylvania Waterworks Association, Virginia State Firemen's Association.

Respectfully submitted,

John R. Freeman, *Chmn.*
E. V. French, *Vice-Chmn.*
Albert Blauvelt
F. M. Griswold
H. F. J. Porter
T. W. Ransom
I. H. Woolson

Sub-Committee on Fire Protection

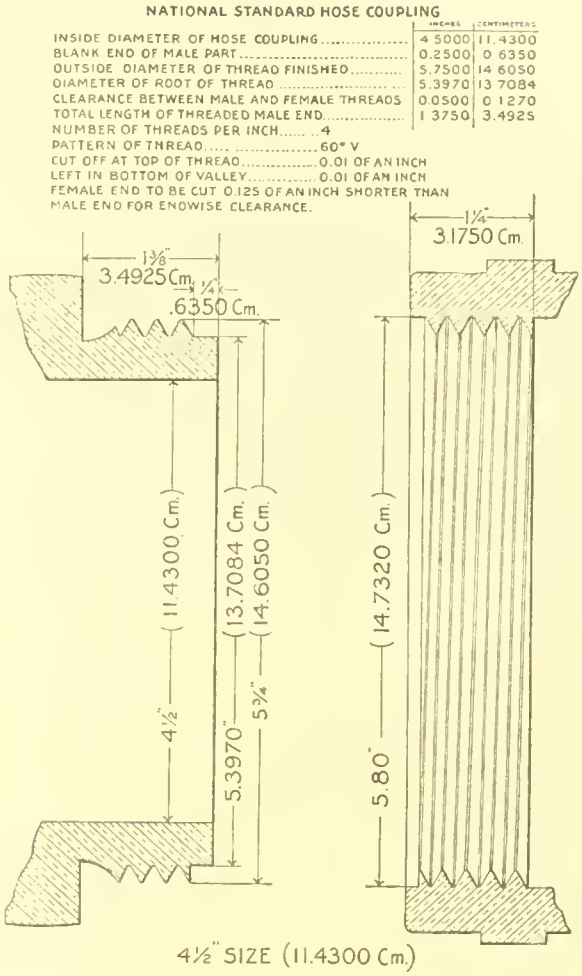

Fig. 4 Details of 4½-In. Coupling

NECROLOGY

CHARLES H. CORBETT

Charles H. Corbett was born in Buffalo, N. Y., on March 19, 1842, and was educated in the schools of that city. In 1858 he entered the employ of the Rogers Locomotive Works, Paterson, N. J., as an apprentice. His work was in the shop and drawing room, and during the latter part of the construction of the U. S. iron clad steamer Keokuk he was employed as assistant superintendent. In 1863 he identified himself with the Continental Iron Works of Brooklyn, of which he was a vice-president at the time of his death on January 14, 1914, working up from the position of draftsman to chief draftsman. He had a prominent part in the plans for the construction of various gas works throughout the East, notably at Boston, Worcester, Salem, Mass., Providence, R. I., and the various gas works of New York now merged in the Consolidated Gas Company. When the Continental Works was incorporated in 1887 he was made second vice-president.

He served the Society as Manager from 1901 to 1904.

DAVID N. MELVIN

David N. Melvin, for forty years superintendent and general manager of the American Linoleum Manufacturing Company of Staten Island, died in Miami, Florida, on January 27, 1914. He was born in Glasgow, Scotland, on July 21, 1840, and was graduated from the Andersonian University of Glasgow in 1860. For several years he was employed by Crawhall & Campbell, as engineer and draftsman, and later designed fireproof buildings and machinery for sugar refining mills in Scotland, Cuba and the West Indies. He afterwards purchased an interest in a paper mill near Oxford, England, which he operated until the abolition of the British tariff on paper made the business unprofitable.

Shortly after his arrival in America in 1867 he obtained a patent for an improved sectional safety steam boiler and later an automatic furnace door and a high-pressure engine. He also formed a connection with T. A. Weston of Buffalo, inventor of the differential chain pulley, and subsequently engaged in the erection of large buildings in the Michigan lumber region. In 1873 he became associated with Frederick Walton, the inventor of linoleum, and erected an extensive plant at Long Neck, S. I., which has grown to be one of the largest of its kind. In 1888 when the Walton patents expired, Mr. Melvin invented what is known as inlaid linoleum, and later wood inlaid, which have since been extensively manufactured under his patents.

Mr. Melvin was a member of the American Society of Civil Engineers and of the Richmond County Automobile Society.

WALTER AMBROSE PEARSON

Walter Ambrose Pearson was born in Putnam, Conn., on July 3, 1869, and died in New York on January 25, 1914. He was educated at Tufts College, Mass., where he was graduated in 1890 with the degree of B.A. Immediately afterward he entered the employ of the West End Street Railway Company of Boston, which was then going through the early stages of electric railway development. Mr. Pearson was employed first as a station operator.

In 1893 Mr. Pearson went to Brooklyn, N. Y., to take charge of the electric installation of the Brooklyn Heights Railroad Company, as electrical engineer, and in 1896 undertook similar work for the Metropolitan Street Railway Company of New York. Here he was active in the development of the Lenox Avenue underground electric system, the first to be developed in this country. In 1906 he went to Niagara Falls for the Electric Development Company of Ontario, in charge of the electrical installation and construction of this company's power house at Niagara Falls.

In 1910 Mr. Pearson went to Rio de Janeiro, Brazil, remaining for two years as assistant general manager of the Rio de Janeiro Tramway, Light and Power Company. Poor health due to climatic conditions forced his return and he became associated with the banking house of Bertron, Griscom and Company as consulting engineer, with which he was connected at the time of his death.

He was a member of the American Institute of Electrical Engineers, the New York Railroad Club, and the Engineers Club of New York, and was prominent in Masonic circles.

FRANKLIN PHILLIPS

Franklin Phillips, president of Hewes and Phillips Iron Works of Newark, N. J., died in that city on February 9, 1914, after a brief illness. He was born in Newark in 1857 and was a son of John M. Phillips, founder of the Hewes and Phillips company.

He was educated in the public schools and at Stevens Institute of Technology and Cornell University, graduating from the last in 1878, and immediately entering his father's firm, in which he was active up to the time of his death.

Mr. Phillips had a broad reputation as a steam and hydraulic engineer and was frequently called into consultation by eminent engineers in relation to large engineering projects. He was president of the New Jersey Foundrymen's Association and was actively interested in all civic movements that had for their object the prosperity and upbuilding of his city and state. He was a member of the Newark Board of Trade and of the Essex Club and was quartermaster sergeant of the Essex Cavalry Troop and had been major and inspector of small arms of the New Jersey Second Regiment of Infantry.

GEORGE C. SCHOFF

George C. Schoff was born in Annapolis, Md., on September 28, 1867, and was educated at St. Johns College and at the University of Arkansas, Fayetteville, from which he received the degree of C.E in 1889. After his graduation he remained at this institution as an instructor and assistant professor for several years.

In 1893 he became associated with J. M. Witham of Philadelphia, consulting engineer, as first assistant, resigning in 1895 to enter the Philadelphia sales office of the Babcock and Wilcox Company, where he remained until the time of his death, January 21, 1914. He represented the company in the design of a number of large power plants throughout eastern Pennsylvania, Maryland and Virginia.

Mr. Schoff was a member of the Union League Club of Philadelphia.

ARTHUR PIERCE TRUETTE

Arthur Pierce Truette was born in Boston, Mass., December 28, 1888, and died in Brookline, Mass., on December

17, 1913. He was educated in the Allston Grammar School of Boston and at the Brookline High School, and was graduated from the Massachusetts Institute of Technology in 1910. He acted as assistant at the Institute for one year and in August 1911 entered the service of the Goodyear Tire and Rubber Company, of Akron, Ohio, as power plant engineer, remaining with them until shortly before the time of his death. During his brief connection he reorganized and doubled the capacity of the company's power plant.

Mr. Truette was a member of the University Club, the Goodyear Technology Club and the Chamber of Commerce of Akron, the Northern Ohio Technology Club, the New York Technology Club, and the Appalachian Mountain Club of Boston.

MEETINGS

MEETINGS IN MINNESOTA

A meeting of the members of the Society was held in St. Paul on January 7, and was made the occasion of a lecture on the American Railroad Ditcher, by Oliver Crosby. The lecture was illustrated by moving pictures and proved most profitable and entertaining.

On February 11 there was a meeting of the Minnesota members in Minneapolis, a talk being given by C. L. Pillsbury on the Construction and Mechanical Details of the Minnesota State Prison at Stillwater. This was illustrated by numerous lantern slides. A discussion followed and Prof. Wm. H. Kavanaugh of the University of Minnesota, who was in charge of the 48-hour test, gave an interesting report with reference to the economy of this plan.

CHICAGO MEETING, JANUARY 28

A meeting of the Chicago Section was held in the Hotel Sherman on January 28. W. F. M. Goss, Past-President of the Society, welcomed the members and guests, and a paper on Boiler Tests with Illinois Coal, the Taylor Stoker and Four-Pass Edge Moor Boiler being employed, was presented by Bryant Bannister of Kewanee, Ill. Prof. G. A. Goodenough, Jos. Harrington, J. B. Brydon, R. H. Kuss, T. A. Marsh, A. Bement, J. C. Bannister, P. A. Poppenhauser and F. C. Gasche participated in the discussion. An abstract of the paper and discussion will appear in a later issue of The Journal.

A banquet preceded the meeting at which there was an attendance of 140.

BOSTON, FEBRUARY 4

A joint meeting was held at Boston in February by the Society in conjunction with the Boston Society of Civil Engineers and the American Institute of Electrical Engineers, the meeting being devoted to the general topic of Recent Developments and Present Tendencies in Railroad Work. Three papers were presented, one devoted to Rolling Stock, by Henry Bartlett, general mechanical superintendent of the Boston & Maine Railroad; another on Electrical Equipment, by Frederic D. Hall, electrical engineer of the Boston & Maine Railroad; and a third on Permanent Way, by A. B. Corthell, chief engineer of the Boston & Maine Railroad.

Mr. Bartlett, in the opening paper, confined his remarks principally to the development in locomotives in their relation to the greatly increased weights of trains and service requirements. He traced the development of the locomotive from the light eight and ten-wheel locomotives of 20 years ago to the powerful and efficient locomotives of to-day with superheaters, piston valves, Walschaert valve gear and many other refinements. He pointed out the interesting fact that the proportionate increases in power and weight of locomotives have been an important advantage rather than otherwise, in that with the increased weight has come provisions for more ample heating surface and larger grate areas, enabling the locomotive to deliver its rated tractive power with the consumption of less fuel. Reference was made to the tendency in freight haulage toward the use of articulated compound locomotives, and recent tests were quoted which show marked economies resulting from such practice. One of the most interesting features of the paper was the reference to the recent tests by the Pennsylvania Railroad at its Altoona testing plant of Pacific type locomotives, which showed the remarkable result of a horsepower-hour delivered upon 16.4 lb. of water and 2.66 lb. of coal; this has established a record and is of interest in contrast to the best record of 20 years ago, namely, 27 lb. of water and 4 lb. of coal per h.p-hr.

Mr. Hall, in discussing electric equipment problems, expressed disappointment at the slow growth of heavy electric traction and attempted to trace some of the reasons therefor. He pointed out that with present developments and improvements in steam locomotive operation, the electrical system of operation has little to offer from the standpoint of economy; it must therefore come from other reasons of advantage, such as more satisfactory or more reliable operation. The development of heavy electric traction was shown to be considerably hampered by the great diversity of opinion among engineers as to the most desirable method of electrical operation, the voltage to be used, or some of the other important factors in connection therewith. He suggested the advisability of some concerted action in regard to standardization of these elements, possibly in conjunction with the American Railway Association.

Mr. Corthell discussed extensively the general subject of track and track work, starting with historical development and the tracing constructional and detail changes up to modern practice. He devoted much thought to rail design, referring to the adoption of standards by the American Society of Civil Engineers and the American Railway Association. Some experiments upon so-called frictionless rails were reported and the effect of wear on them in curves noted. The paper treated also of rail joint fastenings rather completely and also the subject of tie-plates was discussed, in its relation to tie preservation.

ST. LOUIS MEETING, FEBRUARY 4

At a meeting of the Associated Engineering Societies of St. Louis at the Engineers Club on February 4, J. Irvine Lyle, manager of the Carrier Air Conditioning Company of America gave an interesting lecture on Air Conditioning. The paper was discussed by R. H. Tait, Edw. Smith, John Hunter, Hans Toensfeldt, H. H. Humphrey, E. H. Ohle, and L. C. Nordmeyer.

PHILADELPHIA MEETING, FEBRUARY 9

The members of the Society in Philadelphia held a joint meeting on the evening of February 9 with the American Institute of Electric Engineers at the Engineers Club. A din-

ner preceded the professional program at which there was a large attendance.

The subject for the evening was Business Training for the Engineer, the speakers being Dr. Alexander C. Humphreys, Past-President of the Society and President of Stevens Institute of Technology, who emphasized in his remarks the necessity for familiarity on the part of the engineer with business methods, including accountancy. At Stevens, he said, every student was obliged to take a course in the business features of engineering practice, and many, who did so under protest, were afterwards willing to acknowledge the valuable aid it had been to them. Dr. Humphreys was followed by Theodore L. Jones of the Edison Illuminating Company of Brooklyn, who spoke extemporaneously.

The speakers' remarks were discussed by H. H. Norris, Walton Clark, Henry Hess, C. H. Bigelow, G. A. Hoadley, H. V. Schreiber, C. V. Wein, W. C. L. Eglin, M. N. Miller.

CINCINNATI MEETING, FEBRUARY 12

A joint meeting of the Cincinnati Section and of the Engineers Club was held on the evening of February 12. J. Irvine Lyle, manager of the Carrier Air Conditioning Company of America, gave an address on Air Conditioning in which he mentioned the great influence of atmospheric conditions upon the quality and quantity of the product in textile mills, soap factories, bakeries, printing, lithographic and other industrial plants. Many instances were cited in which artificial changes of temperature and particularly of humidity had produced a direct saving in costs and greatly increased the output, the reasons for the improvement being given in each case. Mr. Lyle reviewed briefly the theory of air conditioning and explained the use of psychrometric charts in this connection. He gave illustrations of the saving of delicate fabrics in large stores by the elimination of dirt from the air sent into the buildings for ventilation, the reduction of temperatures by the introduction of humidified air and the limits of the reduction of temperature possible by this means being illustrated by calculation. Various washers and automatic humidifying devices were shown and their uses illustrated.

A large number of lantern slides and some apparatus were used to illustrate the lecture, and a general discussion followed. About 100 attended the meeting, which was followed by a lunch.

NEW YORK, FEBRUARY 10

An interesting meeting of the Society was held in New York on February 10, under the joint auspices of the New York Committee on Meetings and the Sub-Committee on Railroads. The paper of the evening, Brake Performance on Modern Steam Railroad Passenger Trains, was delivered by S. W. Dudley, assistant chief engineer of the Westinghouse Air Brake Company, Pittsburgh, Pa. The data presented are the result of an important series of tests made by the Pennsylvania Railroad in conjunction with the Westinghouse Air Brake Company, which were carried on for a number of months during 1913 with a heavy steel car passenger train and 40 observers, to determine many points of importance in the safe handling of heavy trains.

The tests were divided with a view to investigation of the five important factors in train braking separately, as follows: (*a*) The air brake mechanism proper, (*b*) the foundation brake rigging and percentage of braking power that can be adopted, (*c*) the method of application of the brakes, (*d*) the behavior of the brake shoes, and (*e*) the coefficient of friction between the wheel and rail. Under (*a*), the performance of the new type VC air brake system with electro-pneumatic control was compared in all details with the present commonly used type PM high-speed brake equipment, and the advantages of the improved system studied. The percentage of braking power, (*b*), was studied in its relation to the more efficient action of the improved brake system, with a view to considerable increase and very material benefits were thereby derived. The investigation of the method of application of the brakes, (*c*), was a comparison of the present single shoe method with the clasp-shoe method of brake rigging (two shoes per wheel) from which such important advantages are derived. The study of the behavior of brake shoes, (*d*), forms one of the most important laboratory investigations of brake shoes ever attempted, and brought out much information of value. The study of rail friction, (*e*), was to determine the limitations imposed by rail conditions upon braking practice and developed many new ideas. The paper as a whole created unusual interest and elicited a spirited discussion, which centered mainly around the new electro-pneumatic brake system.

SAN FRANCISCO MEETING, FEBRUARY 10

A meeting of the San Francisco Section was held in the rooms of the Engineers Club of San Francisco on February 10, the topic of the evening being the Transportation of Crude Oil in Pipe Lines.

E. I. Dyer, engineer-in-chief for the Union Oil Company of California, led the discussion by reading a paper prepared with special reference to experimental work on one of the oil pipe lines of his company, to determine the various factors influencing the loss due to friction in pumping oil through pipe lines, and the derivation of formulae by which the friction losses could be calculated. Mr. Dyer demonstrated his results by a series of curves plotted from a large number of field observations and combined all of the variable factors in one, which he has termed the viscosity coefficient. This viscosity coefficient takes into consideration also the element of time, which is an important factor in giving the change in the viscosity of the oil as it cools or is heated.

He was followed by Wynn Meredith, Mem.Am.Soc.M.E., H. W. Crozier, engineer for Sanderson and Porter, A. C. McLaughlin, superintendent of operation for the Kern Trading and Oil Company, E. T. Morris, manager of the Associated Pipe Line Company, and A. F. L. Bell, chief engineer for the Associated Oil Company.

H. T. Cory called attention to the confusion due to the many different standards in vogue in the oil fields, with special reference to the characteristics of the various types of oils. Robert Sibley, A. M. Hunt, and W. F. Durand were appointed a committee to investigate the matter and report to the Society such recommendations as in their opinion should be carried out to correct this condition.

About 80 were in attendance, among them members of the Student Branch of the University of California.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

THE man who can make twice as many pounds of steam from a pound of coal as was made before would, in a way, confer on humanity almost as great a benefit as the man who makes the proverbial two blades of grass grow where one grew before. Whether the new Brünler type of boiler, with the flame projected directly under the water, does it, cannot be yet considered to be established by properly conducted tests, but it appears to be an invention having important possibilities.

THIS MONTH'S ARTICLES

At the basis of modern power generation lies the great question of fuel, and what Sir Roverton Redwood, a prominent British authority on oil, says with respect to the future possibilities of liquid fuel, is of particular importance in this country where the Diesel oil engine is now being introduced. In the same connection the article of Praetorius will be of interest. Hellman shows how by a proper design of admission valves and proper use of the scavenging process the output of a gas engine may be increased approximately 25 per cent, at the cost of only a slight increase in power consumption at the scavenging blower.

The section on Steam Engineering is of particular interest in this issue. Gwosdz describes the Greis smoke consuming apparatus and method of smoke prevention (improved type). Another abstract tells of the locomobile driven central station in Wiborg, Finland, remarkable for its economic design and low cost of power production in pounds of steam per kilowatt generated. In fact the plant is so designed that it works practically all the time at its most economic loads, and is at the same time perfectly able to take care of all peak loads.

The report of the German investigation of the turbine situation in that country is concluded: it gives interesting data as to the turbine costs, efficiency at partial loads, and power reserves in turbine driven central stations (the latter appear to be suspiciously large). From a Russian paper is abstracted the beginning of an investigation on loss of heat of locomotive boilers through cooling, in which, probably for the first time, an attempt is made to fully consider the variation of the coefficient of cooling as a function of the shape of various parts of the locomotive surface, its speed of motion, influence of wind, etc. The abstract will be continued in an early issue. The question of the influence on the life of boilers of impurities in the feedwater, and in particular the way their presence produces bulging of tubes, is discussed in two reports presented to the general meeting of the International Association of Boiler Inspection Societies; in the next article A. Gramberg thoroughly investigates the processes of water heating by steam, and compares, for output and efficiency, the parallel flow and counterflow principles.

In the section on Materials is given an abstract of an investigation (in Austria) on telegraph poles affected by fungus, and an abstract of an article by Professor E. J. Coker, of London, on optical methods of testing stresses in structures, giving the theory of this new method and showing some of the apparatus used.

In the second section of the Engineering Survey, the Engineering Societies, is presented a report to the American Concrete Institute, a new organization with a big field before it, on methods of tests of concrete materials. In papers before other societies are described a drag line excavator, tests of ten ton ice machine, and commercial tests of internal combustion engines (with a discussion of the importance of knowing the mixture strength for properly understanding the action of an engine); R. Thomas, in a paper before the Institution of Marine Engineers (British) gives valuable data on some gyroscopic phenomena.

FOREIGN REVIEW

Firing

GREIS SMOKE-PREVENTING DEVICE (*Rauchverhütungsapparat System Greis*, Gwosdz. *Zeitschrift für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 50, p. 607, December 12, 1913. 3 pp., 8 figs. *d*). The article describes an improved type of a smoke-preventing apparatus devised by Jakob Greis, as well as an older type of this apparatus. The principle of the apparatus is illustrated in Fig. 1A, which shows the position of the parts immediately after charging the fuel, with the door closed. Before the fuel was charged the valve *a* was in its highest position, thereby providing for complete closing of the opening in the fire door, while the weight *b* was in its lowest position, the entire apparatus being therefore cut out. When the fire door is opened, the valve *a* at first remains in its highest position while the weight *b*, with the piston of the brake cylinder *c* rigidly connected with it, is drawn upwards and comes to its highest position; thereby the lever of the steam stop valve *d* is raised so that the steam can flow freely from the boiler through the pipes *e*, *f*, *h*, and the nozzle *g* over the fire, and through *i* under the grate in the form of a fine steam vapor.

When after the shifting of the fire and charging of fresh fuel the fire door is closed again, the weight *b*, on account of the resistance of the fluid in the cylinder *c*, still remains in its highest position, while the valve *a* comes to its lowest position shown in Fig. 1A. This provides for the opening in the fire door being opened and for the admission of the air to the fire. But in doing that, the air strikes the hot plate *k* provided with small openings and reaches the fuel considerably preheated. The steam coming out from the nozzle *g* forces the fresh air on to the fire, and at the same time the particles of coal and flue gases, which are all the time in turbulent motion, mix very closely with the steam and fresh air and are fully burned up either on the fire itself or in the flue passages. This action is helped out by the action of the steam entering through nozzle *i*. The weight *b* presses on the liquid in the brake cylinder *c* which gradually passes through a little adjustable valve at the bottom and a special passage into the free space above the piston. The weight therefore gradually comes down and forces the valve *a* upwards which shuts off the admission of fresh air. At the same time the steam valve *d* is also closed. When the valve *a* reaches its highest position and the weight its lowest position, the apparatus has ceased to act, but begins all over again when the fire door is opened anew.

In the improved type of apparatus the brake cylinder has been built much shorter than before, owing to the use of double rolls, which gives a more convenient position and shape to the counter weight and makes the entire apparatus much shorter and more compact. The entrance of steam into the valve *d*, Fig. 1B, is no longer from below with a lateral exit, but the reverse: the steam comes in from the sides and goes out downwards. The method of regulating the brake liquid is also changed: the piston rod of the brake cylinder piston has large openings for letting through the liquids (oil) and a plate valve is located under the piston. The operation in the latest type is as follows: As

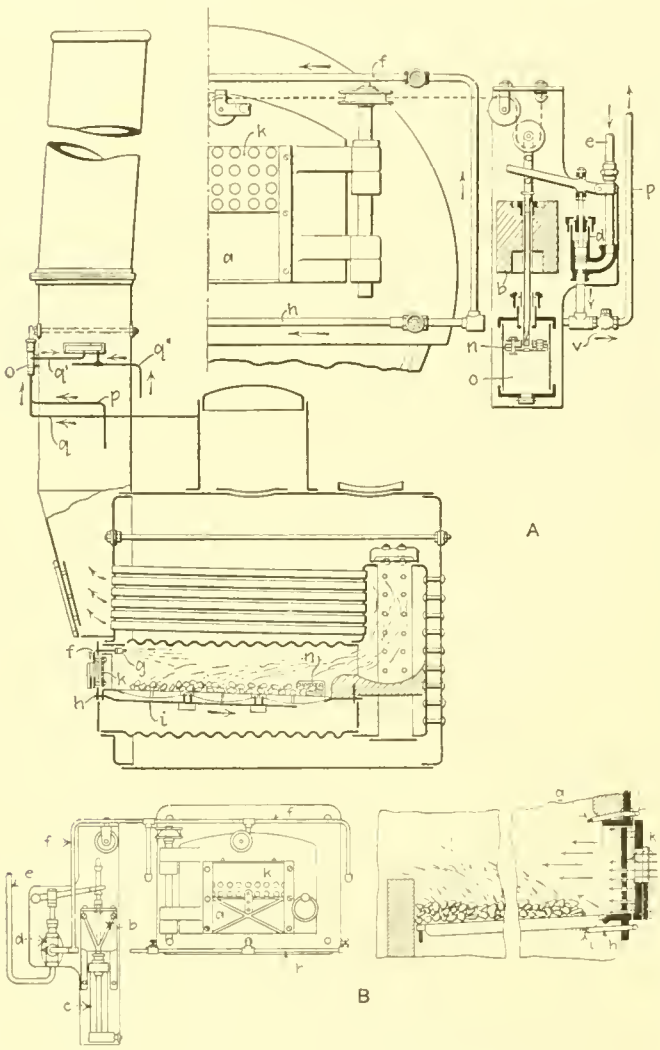

Fig. 1 Greis Smoke Preventing Apparatus

soon as the weight *b*, with the piston connected to it, is drawn up by the opening of the fire door, the plate valve falls down and opens the large openings in the piston to the free passage of the liquid. As soon as the counter weight begins to act on the brake liquid, the plate valve closes the large openings in the piston and the liquid must flow upwards through the hollow piston rod and regulate the valve *m* therein. In order to flow out again through the little holes in the piston rod above the piston, the slower or faster sinking of the weight *b* may be regulated by hand by means of a spindle traveling in the hollow piston rod, the latter being protected from bending or jamming.

In connection with this apparatus, special provision is made to take care of such soot and ashes as may still be carried off by the flue gases. It consists of a cylinder provided with two bores of unequal dimensions and corresponding pistons. The piston rod, which at the same time acts also as a piston for the smaller bore of the cylinder, is given a form such that its lower part may be used as a valve and the upper part as a geared rod. The larger bore of the cylinder *o* is connected with the pipe *p* and the smaller bore with the pipes *q″* and *q′*, while in the dividing wall between the two cylinder bores are located the small passages *r*. In the smokestack a dividing damper, *s*, is provided, having a little gear wheel in mesh with the geared rod of the piston; further, a combined water and steam nozzle, *t*, located at the smokestack at right angles to cylinder *o* and connected by the pipe *q′* with the cylinder *o* and by the pipe *q″* with the water tank. There is also a water pocket, *u*, on the side opposite to the location of the nozzle *t* and placed in a cut in the smokestack wall. It is connected with the steam valve *d* of the smoke-preventing apparatus only by the pipe *p* and receives besides fresh steam from the boiler through the pipe *q*. The operation of the apparatus is as follows: When the smoke-consuming apparatus is not in action, all steam admission is cut out and the dividing damper *s* in the smokestack is in its vertical position, thus affording a free path to the hot gases rising through the smokestack. But as soon as the fire door is opened, the steam stop valve *d* is opened also and the steam can freely flow through pipe *f* to valve *g* over the fire, pipe *h* to nozzle *i* under the grate as well as to nozzle *n*. It can also reach the cylinder *o* through pipe *p* and there raise the piston, the latter by its gears turning into horizontal position the damper *s* so that a part of the gases has to go through the water pocket, which is of such dimensions that by this arrangement the cross-section of the smokestack is not reduced. At the same time the live steam pipe *q* and the pipe *q′* leading to the combined water and steam nozzle *t* are opened, so that the steam coming through from the boiler or through the live steam piping can freely flow through pipes *q* and *q′* and nozzle *t* into the water pocket. By the suction of the steam in nozzle *t* water is sucked in through pipe *q″* and is mixed in the nozzle *t* with steam and is drawn out through the smokestack into the water pocket in the form of a mixed steam and water fog. This steam and water fog flowing at considerable speed in a state of fine division strikes the gases rising upwards and by its action the unconsumed smoke and soot particles as well as ashes drawn up by the fuel gases are saturated with wet steam and sink in the water pocket, while the clean gases pass out into the air through the smokestack.

This process of washing the hot gases flowing through the smokestack continues as long as one of the smoke-consuming apparatus on the boiler is in operation. The apparatus does not act until the fire door is opened, which represents the beginning of the period when the conditions are particularly favorable to an evolution of black smoke.

Hydraulics

New Method of Graphical Presentation of the Fundamental Equation of the Turbine Theory (*Eine Neuerung in der zeichnerischen Darstellung der Hauptgleichung der Turbinentheorie*, A. Pfeiffer. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 36, p. 561, December 30, 1913.

3 pp., 7 figs. *t*). Interesting article, not suitable for abstracting. The author shows how, by an assumption of certain auxiliary values, the normal Camerer diagram for water turbines may be simplified; thus, while the Camerer diagram requires the determination of eight points, the author's diagram may be drawn with only five points, and with greater precision.

Internal-Combustion Engines

Tests at the New Testing Laboratory of the Automobile Club of France (*Les essais du nouveau laboratoire de l'Automobile-Club de France*, G. Lumet. *La Technique moderne*, vol. 6, no. 1, p. 5, January 1, 1914. 3 pp., 6 figs. *d*). The article describes the new laboratory for testing automobile engines and making other tests in connection with automobiles, installed by the Automobile Club of France in its new house at Neuilly-sur-Seine. One of the first problems of such a laboratory is to make provision for the convenient placing on the testing stand of the engine to be tested. In the present case, this problem has been solved in the following manner: The engine is brought into the testing room on a light truck which can carry about 2 tons. To be properly tested, the engine must be placed on the stand conveniently with respect to the brake arrangement, for which purpose each stand is provided with universal brackets designed in a manner such that the engine may be properly placed no matter how wide apart may be the bearing screws. The engine jacket must be cool; the gases of combustion taken away and necessary electrical connections established. There is therefore quite a complicated system of connections and the pivoted bracket held against the wall is arranged so that water, electrical current and exhaust pipes, etc., are all conveniently located. Some of the special appliances used in this laboratory are of particular interest: First, there is a stand for testing the thrust of the propeller at a fixed point. Connected to the propeller is a calibrated speed gear change to which is directly coupled a dynamometer for measuring the force as used, a device recently adopted by engineer Sabatier on the Bayard-Clément dirigibles.

For measuring oscillation effects, a trepidator is used consisting of a heavy plank carrying a small dynamo which is provided on the axis with a heavy mass located eccentrically with respect to the axis of the dynamo. This plank is supported at its extremities in a manner such that when the dynamo begins to rotate, it is given different oscillations which may be measured by an accelerometer. (The Auclair and Boyer-Guillon type is used.) This apparatus, as well as the vibrometer of Guiche-Carlo-Bouret is used to determine the properties of various suspensions of automobile carriages and the influence of oscillations upon their structure, for the determination of which a mixed commission is appointed, consisting of members of the Central Society of Architects and the Technical Commission of the Automobile Club of France.

In connection with these tests of various engines, on the outside of the laboratory a number of fans placed under awnings are provided. The cardan shafting connecting the engine of the fan passes through a special window in the wall of the laboratory. One of the integrating revolution counters has also a shaft which passes through the wall, while close to the counter is placed a controller of angular speed designed by Venton-Duclaux. This apparatus has a little dynamo which takes care of the unrolling of a strip of paper while two electro-magnets record on this strip of paper every thousand of revolutions and every minute of time from the instant the current is switched in.

The article describes also the apparatus designed for the investigation of accessories such as carburetors, mufflers, and ignition, as well as for the investigation of fuels.

Fuel Supply and Governing of Heavy Oil Engines (*Brennstoffzuführung und Regulierung der Schweröl-motoren*, Praetorius. *Der Motorwagen*, vol. 16, no. 34, p. 857, December 10, 1913, and vol. 17, no. 1, p. 1, January 10, 1914. Serial article, not finished, *d*). In the present article the author proposes to investigate the methods of fuel injection and governing of heavy oil engines which he does by describing a number of systems used in this connection and from time to time indicating data of tests. Only such of the systems as are comparatively little known in this

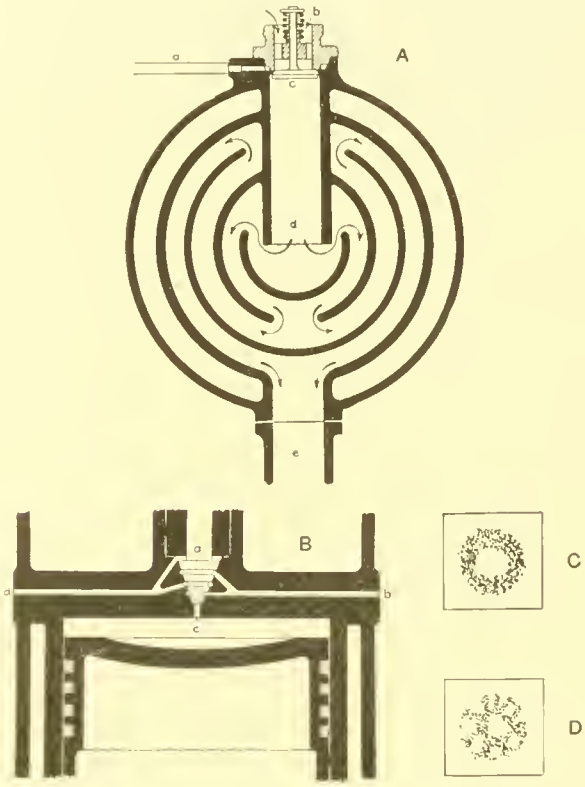

Fig. 2 Fuel Regulation Devices, Heavy Oil Engines

country will be here reported. One of the main problems is to produce a close and uniform mixture of the fuel and air. The Dürr Patents Company uses the device shown in Fig. 2A for this purpose, the fuel entering through *a* and the air through *b* with the valve *c* acting as an atomizer. The mixture is then conducted by pipe *d* into a labyrinth arrangement where it moves in the directions indicated by the arrows and where it is expected to become more intimately mixed. The mixture flows out by the pipe *e*.

A different system is used by Hindlmeier, Fig. 2B. The fuel valve *a* is provided on its seat with several grooves, alternating ones of which take up air and fuel. The fuel is brought in by *b*; compressed air by *d*. When the valve is lifted the air flows in between the fuel streams and forces it violently into the combustion chamber through the opening *c*, which results in the production of a good mixture.

Since a nozzle device is used in several types, the author gives a simple method for testing whether the nozzle is clean or partially clogged up. He recommends the taking off of the cover of the nozzle and instead of the plate *H* (he refers in this case to the Bergsund type of vaporizer, for which see *The Journal*, November 1912, p. 1882), a piece of paper is placed in front of the nozzle opening, and a short quick stroke of the fuel pump throws against this piece of paper a certain amount of the fuel. From the appearance of the deposit on the paper one can see whether the nozzle is clean. Thus the deposit shown in Fig. 2C indicates a partially clogged nozzle while that in Fig. 2D shows a clean nozzle.

Note on the Compression of Real Gases (*Note sur la compression des gaz réels*, H. Brot. *Revue de mécanique*, vol. 33, no. 6, p. 551, December 31, 1913. 9 pp., *mt.*). Article not suitable for abstracting. The author attempts to apply the usual thermodynamic equation derived for perfect gases, to real gases, assuming that the latter follow the van der Waals equation, and obtains some interesting results. Thus (*a*) he proves that: the heat produced by the compression of a real gas is equal to the sum of the work of internal pressure and the external pressure on the gas; and (*b*) he derives the equation of the adiabates of a real gas, general equations of transformation, and determines the mechanical work necessary to produce an isothermal compression of a real gas, as well as that for producing a non-isothermal compression ("if the initial and final pressures are low, the work of adiabatic compression of a real gas is less than the work of adiabatic compression of the same gas assumed to be perfect and under the same conditions of initial and final volume").

Increase of Specific Output of Four-Stroke Cycle Gas Engines (*Steigerung der spezifischen Leistung von Viertaktgasmaschinen*, W. Hellmann. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 3, p. 105, January 17, 1914. 3 pp., 11 figs. *de*). The present article describes the constructional details of design to increase the output of a gas engine by about 25 per cent, continuously, at a cost of an additional expenditure of power of about 2½ per cent on the scavenger blowers, while, as the author claims, notwithstanding this increased output, the engine works at exhaust pressures not higher than other large gas engines (which is due to the fact that the compression space is only moderately increased). The thorough scavenging and the charging of the cylinder with gases and mixing air at atmospheric temperature reduces all the temperatures still farther, as modern experiments have shown. By this means essentially bettering the utilization of the heat content of the gas is obtained. A thorough scavenging is secured by giving generous dimensions to the cross-section of passages for the compressor air (see Fig. 3A) by giving sufficient time for scavenging processes Fig. B, and by using scavenger air at a pressure of 2500 mm. (100 in.) water. Fig. A shows the admission valve gear for compressed air scavenging and quality regulation for a large gas engine with an admission valve of 410 mm. (16.2 in.) in diameter. The external drive of the gear is in accordance with the general design of scavenger in large gas engines. The regulation of the gas supply to the engine by means of a gas flap valve actuated by the governor has already proved its suitability in numerous cases. The admission valve is connected with the seat and guided in the usual manner so that all three can be taken out together from the valve chest. On the valve spindle sits a freely movable cast-iron air piston *a*, which is connected with the mixing-air and compressed-air valve *b* by means of two hollow steel carrier pins, which have on their circumference turned out ringed grooves in which grip corresponding springs belonging to the cast-iron mixing-air and compressed-air valves. The two carrier pins move in the slides *d* of the air cylinder and prevent rotation of the air piston, while the compressed air valve cannot rotate owing to a key screwed into the cover of the admission valve casing. A screwed in and easily accessible pipe *e* conducts the compressed air to an annular passage *f* in the bottom of the air cylinder, governed by the small piston valve *g*, located on the admission valve stem.

The arrow *h* indicates how the compressed air comes under the air piston and raises to its uppermost position the piston valve. The admission valve, which is shown closed, closes in this position by means of the valve stem the passage *i* for the exhaust of the compressed air from the air cylinder. At the beginning of the downward motion of the admission valve the compressed air under the air piston can flow out by means of the slot *d* of the carrier pin, while a further exhaust occurs through the passage *i* which is opened by the valve stem. During the downward motion of the admission valve, and the mixing and compressed air valve *b* outside air flows into the space under the air piston *a* through the passage at *m*. The throttling screw *k* is however adjusted so that above the air piston a small partial vacuum is produced which keeps the valve and air piston in balance. The small check valve *l* acts only during the upward motion of the air piston, if the throttling screw *k* begins to brake the motion too strongly. It must be borne in mind that for the upward motion of the air piston and valve, the period of 2.5 piston strokes is available, which is quite a long time. The oil passage *n* brings oil under pressure to the slide valve *b*, while the air piston *a*, and the admission valve stem are lubricated through the opening *o*. The admission valve with its second packing surface *p* acts simultaneously as a gas shut-off valve. The end ring *q*, turned so as to have a certain play, holds the gas passage somewhat closed at the opening of the admission valve and beginning of compressed-air scavenging until the flow energy of the compressed air forces the gas into the cylinder, up to shortly before the dead point. The mixing-air and compressed-air slide valve moves down automatically, together with the admission air valve under the slight braking action of the small partial vacuum produced over the air piston. During the downward motion the compressed air passage is closed by the valve at about one per cent beyond the dead point and the mixing-air passage remains closed by the valve somewhat longer than that even, so that into the cylinder can flow only clean gas which mixes in the compression chamber with the scavenging air. The duration of the pure gas flow, in accordance with the heating value of the gas, can be maintained up to 30 per cent beyond the dead point, whereafter the mixing-air passage is laid open by the slide valve, gas and mixing air are allowed to flow in until the end of the suction stroke in the usual manner. The mixing-air and compressed-air valves then come to rest in their lowest positions while the admission valve alone moves upward into its final initial posi-

tion. Then only the piston valve turned on to the valve spindle opens a smaller annular passage surrounding it, admitting compressed air under the air piston, and permitting it to raise both the piston and the slide valve into their upper positions. For testing the air piston and its slide valve with respect to ease of run (for instance after long standing) two threaded holes are placed at 180 deg. to each other and the openings *s* are used, the piston and slide valve being moved up and down by means of screws. Openings *s* are then closed again by screws *t*. The gas flap valve *u* is actuated from the governor in the usual manner while the mixing flap valve *v* is adjusted by hand. The arrangement efficiently prevents the formation of a mixture in the valve casing and permits it only after the

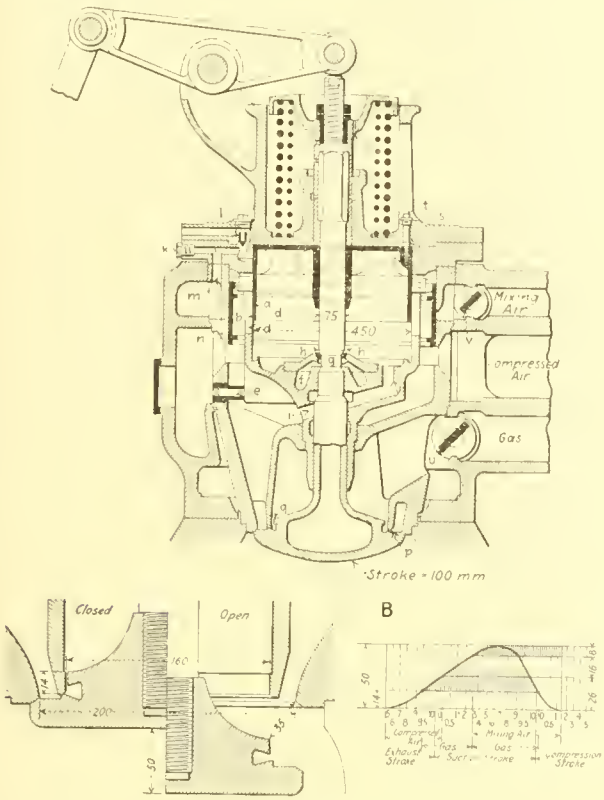

Fig. 3 Gas Engine Admission and Scavenging
A. Gas Engine Admission Valve Gear; B. Admission Valve for Blast Furnace Gas Engine with Gas Having a Heating Value of 700 to 900 WE (1260 to 1620 B.t.u.); C. Valve Gear Diagram for the valve shown in B.

passage through the admission valve. This eliminates backfiring in the valve casing and permits the mixing and compression air valve to move in pure air only. If the gas engine is operated without scavenging, the compression air is shut off and the mixing air and compressed air slide valve is automatically pressed to its lower position while the mixing air passage is kept frequently open. The engine is then operated in the usual manner.

The author discusses further the design of admission and gas valves for gases of various heating values, and shows governor diagrams for blast furnace gas driven dynamos running at a constant speed, and for a blast furnace gas driven blower running at variable speed.

Mechanics

Ruptures of Machine Parts (*Brüche an Maschinenteilen*, Kasten. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 1, p. 4, January 2, 1914. 2½ pp., 10 figs. *d*). The great advantage of the electric elevator consists in the fact that it may be arranged so that the car may always be stopped exactly at the level of the floor, which is of importance especially in the handling of freight.

In the button pressure control electric elevators, the correctness of the stoppage of the car depends to a certain extent on the personal equation of the operator. On the other hand, the electric elevator presents certain advantages, and attempts were naturally made to combine the advantages of both types. The evident way to avoid the disadvantages of rope elevators for the delivery of freight was to replace the load post of the hydraulic elevator by a jack screw in the electric elevator. The author could find no data as to the efficiency of the jack screw type, but it appears certain that it is more economical than the hydraulic elevator. In a large plant, tests have shown that the current consumption for a lift of about 4 meters (13.1 ft.) and a load capacity of 1000 kg. (2200 lb.) is, on the average, about 65 watts. In this type of elevator the influence of the connecting elements of the car and driving engine is eliminated, but the influence of the load, brake and the slowing-down path is present in this type also when the elevator has electric lever or press button control. The elevator therefore always has a tendency to pass its stopping level, and injuries to the electrical and mechanical parts are possible. The proposal to install an elastic element between the jack screw spindle and the car has met with objections, but it is remarkable that no attempts have been made to enable the operator to control the brake directly, as it would appear that it is the one way to make the electric elevator as reliable as the hydraulic.

The author discusses and illustrates a case of a rupture in a jack screw elevator which shows that particular care must be given to the connection between the car and the spindle. He shows also several designs of connecting elements.

Refrigeration

Reversible Absorption Machines (*Reversible Absorptionsmaschinen*, E. Altenkirch. *Zeits. für die gesamte Kälte-Industrie*, vol. 21, no. 1, p. 7, serial article, not finished. *d*). Complete exposition of the theory and construction of absorption and resorption refrigerating machines. Preliminary statements have been published before, in a paper presented to the Third International Congress of Refrigeration (Chicago, 1913), and in various publications (*cp. The Journal*, September 1913, p. 1574).

Steam Engineering

Brünler Boiler with Underwater Firing (*Die Unterwasserfeuerung System Brünler*, Jaeger. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 2, p. 13, January 9 1914. 4 pp., 1 fig. *de*). All steam boiler construction has so far been based on the idea of producing heat on one side of a good heat conductor, placing water or a corresponding liquid on the other side of the conductor and endeavoring to transmit as much of the heat produced as possible through the partition to the steam generating liquid. Of course, large heat losses are unavoidable in this process.

From this point of view the system invented by a German engineer, O. Brünler, is decidedly novel since he generates heat directly under water without any heat conducting element between the source of heat and the steam generating liquid. His process is, to a certain extent, a return to the

principle of the so called "Greek Fire" which was in use about a thousand years ago and the method of working of which is still somewhat of a mystery.

Mr. Brünler built his first boiler some six or seven years ago, but the difficulties encountered have been so numerous that the tests had to be given up. Lately, however, an important boiler has been placed at work in a chemical factory in Germany of the Wesenfeld, Dicke and Co., in Dahl near Langerfeld, where it is used for the evaporation of tungstic soda solution. The steam generated cannot be used yet for other purposes because, under the German police regulations, this boiler does not correspond to the approved boiler standards, and may not be placed in regular operation.

The plant consists of the generator proper in which the flame is produced under the water level, and the collector A with the pipes connected to it, a and a_1. This collector

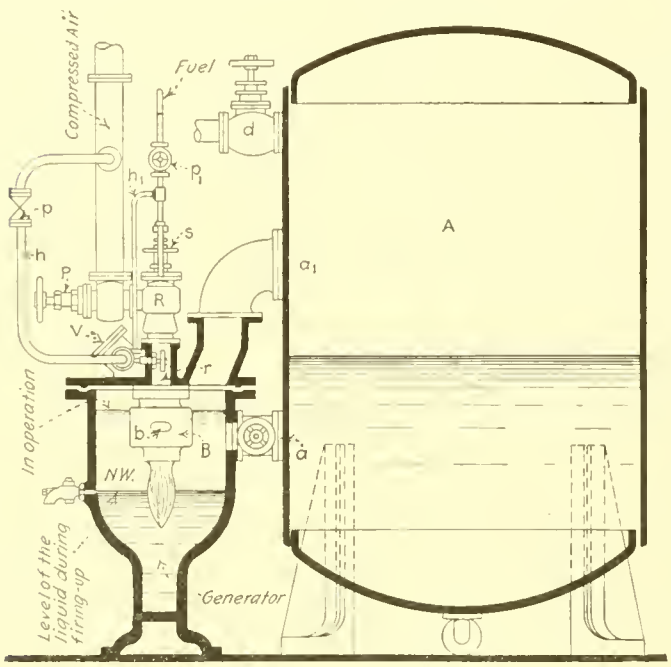

Fig. 4 Brünler Boiler with Underwater Firing

serves for the storage of the liquid from which steam is to be generated as well as a collector of the steam generated and the gases produced in the process of its generation (carbon dioxide and nitrogen). The collector is made of wrought-iron sheets; and the generator in this case of steel casting, which is used because this material resists better the action of tungstic soda solution than would wrought iron.

Tar oil having a heating value of about 9000 WE (16200 B.t.u.) is used as fuel in this case, but producer gas, coke oven gas, or any other gas, can be used with properly designed burners B for each case. The tar oil flows to the burner through a mixing valve R into which is brought laterally the compressed air pipe. The air and fuel admissions are regulated by a governor wheel s. When the firing is started, the valves P and R are closed. After the opening of the valves P and P_1 the tar oil and compressed air pass through auxiliary pipes h and h_1, to the small mixing valve r and from there into the auxiliary vaporizer V. In the latter is located an ignition tube, which when the firing has to be started is brought to a dark glow by means of a torch (to do this, the cover of the vaporizer has to be taken off). The mixture of compressed air and finely atomized tar oil flows through r, is ignited on contact with the ignition tube and in a short time brings it to a bright red glow. There is inserted in the upper opening of the auxiliary vaporizer V a graphite disc which cuts off the ignition tube and forces the gases of combustion to flow through the inner part of the burner B. The latter at b is forked out and forms a hollow cooling space which is in connection with the water level. When the firing is started an adjusting valve at a is kept closed; then so much liquid is let into it from A that the level of the liquid NW is just under the opening of the burner. Through the action of the hot gases of combustion coming from the auxiliary vaporizer V, the upper plate b in the fork of the burner is brought to a red glow in a few minutes, a process which can be observed through a round spy-window in the wall of the generator. When this is so the cover of the vaporizer V is screwed on and the main mixing valve R is adjusted by means of the wheel s after the valve P is opened. The tar oil flowing in is vaporized in the highly heated upper part of the burner B, is ignited at b, and a flame cone is formed at the lower opening of the burner.

After the auxiliary mixing valve r is closed, the valve at a is slowly opened so that the liquid reaches to the upper part of the burner and cools it from outside. As soon as this is done the liquid is brought to violent boiling through direct transmission of heat from the flame cone. The gases of combustion, consisting of carbon dioxide and nitrogen, pass together with the steam generated through the pipe a into the collector A. These gases and steam carry with them large amounts of liquid, the flame acting somewhat like a Mammoth pump so that lively circulation is produced in the collector and generator. The boiling of the liquid in the generator produces a cooling of the cover of the latter so that its external temperature is always below that of the steam.

In addition to that there is an asbestos sheet placed between the burner and the cover so that the hot top of the burner shall not heat the cover too much by conduction. The entire apparatus therefore remains comparatively cool, but if necessary may be covered by heat insulating materials from the outside so as to avoid radiation losses. In no case can the heating of the walls to a glow heat take place, and the worst that may happen is that through lack of water the top of the burner B may come to a glow, perhaps to a white glow, and may even be entirely melted. If this should happen there would be no dangerous results. In the first place the attendant would rapidly observe by the manometer of the collector A that the water level of the latter rapidly falls down, which would indicate that the pressure of the gases in the generator has come down, and would take corresponding steps. In the second place the melting of the burner would produce a closing of the passages, which in its turn would shut off the supply of gas and compressed air, and put out the flame. Should, however, the burner, instead of being melted, develop a side passage for the gases and air, the amount of the flow of gases would be so small that the flame under the action of water would be rapidly extinguished again. The Brünler steam generator, as far as safety from explosion is concerned, is therefore superior to the usual boiler types. A further advantage of this generator is that no boiler scale formation has been observed

even where very poor feedwater and concentrated solutions have been used. When ordinary water is used for feeding the boiler, the favorable result is due to the fact that the carbon dioxide of the gases maintains the carbonates in the water in the form of acid carbonates, $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ in suspension while the sulphuric salts are, as is known, the only ones which, when the point of saturation is exceeded, fall down in a fine powder. There is another circumstance also which contributes to the same effect: in the generator the boiling of the liquid is so intensive that there can be no stationary layers which contribute to the formation of mineral deposits. (Owing to the violent boiling and eddies, the use of a water level glass in connection with the generator is absolutely useless, and a manometer on the collector *A* takes its place to a certain extent.) The salts of the sulphur formation are, of course, deposited in the collector, but form no rigidly adhering scale. Owing to the fact that the collector is not strongly heated they are there only as a sort of mud. The water level in it is also fairly even and is not subjected to constant oscillations or to continual variations, as in usual boilers. There seems to be a complete suppression of steam and gas bubbles on one hand and water on the other in the generator, and the inventor claims that very little steam is given off in the collector. A little distance below the water level the temperature sinks very little below that corresponding to a boiler temperature for the respective steam pressure, and if these data prove to be correct that would explain why so little scale is formed in the collector. It is, of course, clear that the pressure of the air of combustion must be higher than the steam and gas pressure in the boiler, since otherwise the flame would not be able to develop under the pressure coming from the direction of the water level. There is formed around the flame a zone of superheated steam and superheated gases. The latter, in view of the violent formation of eddies in the generator, must separate from the water so fast that they have to reach the collector 30 to 40 deg. cent. hotter than the latter, and in the collector they produce a drying action on the steam and communicate to the mixture of the gas and steam a higher temperature than corresponds to the temperature of saturated steam as given by tables. Although the test made by Wesenfeld, Dicke and Company confirm this fact, still it requires further proof to confirm the claim of the inventor that the fuel, in this case tar oil with a heating value of 9000 WE (16200 B.t.u.), evaporates more water than corresponds to the usual theory of evaporation. This is probably due to the chemical action of ultra violet rays produced in the flame, kept back by the screening action of water, and conducted away by the metal in calorimeter tests from which the theory of evaporation is deduced. Anyhow, it is his claim that in the present tests 1 lb. of tar oil produces an evaporation of 20 to 21 lb. of water from a solution of tungstic soda, while in one test of 36 hours an evaporation of 24 lb. of water per pound of fuel has been obtained as against the theoretically possible evaporation of 14 lb. The article contains a tentative heat balance as well as a discussion of the possible advantages of this boiler.

THE LOCOMOBILE DRIVEN CENTRAL STATION AT WIBORG IN FINLAND (*Das Lokomobilkraftwerk Wiborg in Finland, Annalen für Gewerbe und Bauwesen*, vol. 74, no. 872/2, p. 33, January 15, 1914. 3 pp., 5 figs. *d.* Practically the same article can be found in *Zeits. für Dampfkessel und Maschinenbetrieb*, vol, 37, no. 4, p. 38, January 23, 1914). The superheated steam locomobile has proved to be nearly as economical in its steam consumption as the steam turbine and lately it has begun to be used for continuous power production in large power plants, especially in Northern Europe. The author describes a very interesting installation of this kind in the city of Wiborg in Finland where three superheated steam compound locomobiles, Wolf type, have been placed to supply power and light to the entire city in connection with a small water power plant. The arrangement is as follows: In the daytime the power is supplied by

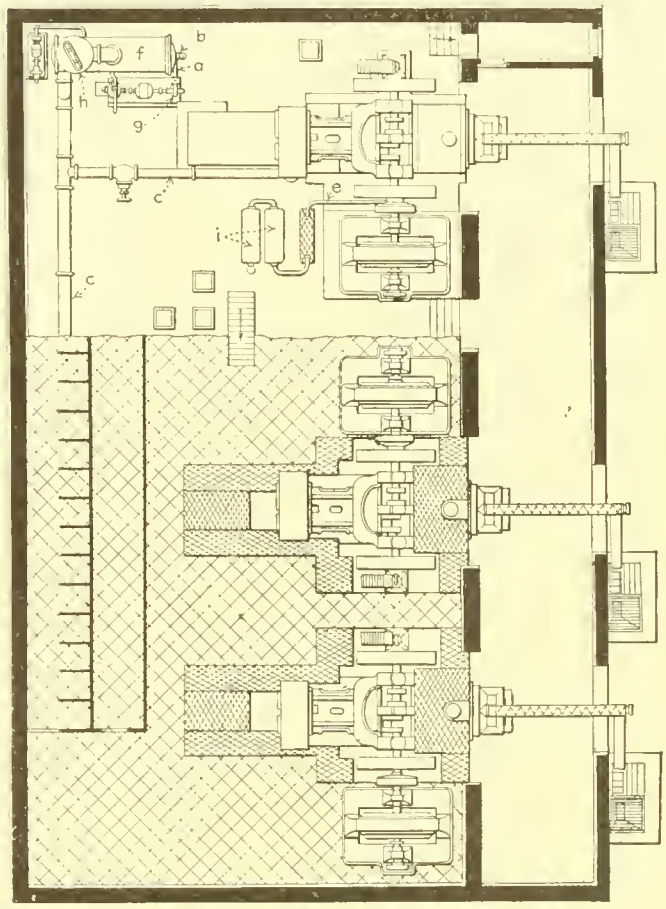

FIG. 5 WIBORG LOCOMOBILE DRIVEN CENTRAL STATION

Piping: *a* supply of circulating water; *b* discharge of circulating water; *c* vacuum piping; *d* boiler water discharge; *e* feedwater suction piping; *f* surface condenser; *g* circulating water pump; *h* steam oil separator; *i* water oil separator.

the hydraulic plant and one of the locomobiles, on which the load varies from 450 to 600 horsepower, that is, it remains continually within the most economical limits of fuel consumption. At dusk the second locomobile is placed in parallel, and in the course of the evening the load of the two locomobiles rapidly rises to about 1200 h.p. so that each locomobile works at its best economic output. In order not to overload the plant a third locomobile is all the time under steam ready to be switched in as soon as necessary. About midnight one of the two working locomobiles can be cut out, the other locomobile together with the water power plant taking care of the remaining load, street lighting and

house lighting. The electrical part of the plant consists of three polyphase generators of the German General Electric Company, 380 kw., power factor 0.8, 3000 volts, 50 cycles, 170 r.p.m.; each generator is directly coupled to a shaft of the corresponding locomobile, the coupling being a flexible band of the Zodel-Voith type, which has an advantage as compared with the absolutely rigid coupling, in that when several machine aggregates are placed in parallel, it prevents dangerous shocks in the generator and tends to damp out hunting. As regards the steam end of the plant, multitubular boilers with withdrawable tubes are used in connection with spiral superheaters, each boiler being provided with separate devices for blowing off steam, for cleaning the boiler pipes and superheater coils. The compound engine is placed on the boiler itself, whereby the constant relation of all the engine parts to one another is secured. The distribution of steam in each of the two cylinders is secured by a simple piston valve with narrow spring packing rings of the R. Wolf type, while the governing is effected by the axle governor connected with the eccentric of the high-pressure piston valve. With due regard to the units being placed in parallel, each aggregate is provided with a regulating device by means of which the speed of rotation may be either raised or lowered within certain limits by a hand wheel acting on the axle regulator. Each boiler has an independent stoking arrangement, the coals being thrown into the loading room under the machine room by means of funnel-shaped openings, and from there taken up to a height of about 5 m. (say 16 ft.) by a screw conveyor which carries them over shutes placed over the firing. Shovel stokers are used for the stoking proper and are driven from the shaft of the locomobile. A part of the space is occupied by the condenser plant which is characterized by the rather novel arrangement, according to which all three units have a central condensation arrangement built by the machine factory of the Balcke Company in Bochum. The exhaust steam flows through pipe *c* which acts as a common piping for all three locomobiles, then through the oil separator for steam *h* and up to the surface condenser *f*. The first water of condensation passing from the steam oil separator, and still containing a large amount of oil, is sucked up by a small centrifugal pump directly connected to a polyphase electric motor. On the other end of the shaft of this motor is a second small centrifugal pump which drives the main water of condensation from the surface condenser *f* through a coke filter to the feedwater tank. The cooling water is brought to the condenser by the piping *a* by means of the cooling water pump *g*. The motor which drives this cooling water pump is connected on its other end to a second centrifugal pump which acts as a vacuum air pump for the condenser. The cooling water leaves the condenser by the piping *b*.

Official tests made at the factory of the builders have shown a fuel consumption of from 0.486 to 0.505 kg. (10.6 to 1.11 lb.) per h.p-hr., and a steam consumption of 4.2, 4.16 and 4.2 kg. (9.24, 9.16 and 9.24 lb.) per h.p-hr., with loads of 556 h.p., 530 h.p. and 525 h.p. respectively, the tests lasting from 3 hours to 4 hours.

Tests on the Influence of Compression and Surfaces through Which is Effected the Heat Exchange in Steam Cylinders, on the Working Process of a Single Cylinder Engine (*Versuche über den Einfluss der Kompression und der Oberflächen, an denen sich der Wärmeaustausch im Dampfzylinder vollzieht, auf den Arbeitsvorgang einer Einzylinder-Maschine,* E. Heinrich. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, nos. 1 and 2, pp. 15 and 58, January 3 and 10, 1914. 12 pp., 26 figs. *etA*). The article presents advance information of a series of tests made in the laboratory of Prof. C. Von Bach.

They differ from similar experiments previously made in that an arrangement was devised by which the areas through which the heat exchange took place could be varied. Both jacket and cover heating were used while in some cases no heating was used at all. The compression varied from 0 to 50 per cent as determined by diagrams taken from the exhaust valve. Steam consumption was determined in two ways: first, by the determining of the amount of steam brought in, and next by measuring the amount of water of condensation. The tests were made in the special laboratory of Professor von Bach, which afforded particular facilities for this kind of work. The boiler *a* (Fig. 6A) a small unit of the Prégardien type, with inclined grate and heating area of 100 qm. (1070 sq. ft.) generates what is called "heating steam," which in its turn produces the working steam. The steam boiler *b*, with a heating surface of 200 qm. (2140 sq. ft.) consists of a group of vertical pipes, its heating surface serving partly for the production and partly for the drying of the working steam. The advantage of this arrangement consists in a precision of measurement of the feedwater otherwise unattainable, especially in short tests, since in this indirectly heated boiler, the water level is nearly absolutely stationary. The steam engine can be used either as a single cylinder, or as a compound engine, or finally as a triple expansion engine with four cylinders, and can be used either with saturated steam or with steam superheated up to 250 deg. cent. (482 deg. fahr.) with a maximum output of about 200 e.h.p. In this case it was used as a single cylinder engine. This engine possesses an important advantage for the present test, in that its compression may be adjusted by hand from 0 to 50 per cent while the engine is in operation. In addition to this, the crank is also adjustable so that the stroke may be reduced from normal dimensions downwards to practically any desired amount, thus permitting it to work with variable clearances. The admission can be varied from 0 to 60 per cent, the speed from 20 to 130 r.p.m., both being adjustable by hand while the engine is running. The cylinder has a stroke of 761.5 mm. with 250.8 mm. bore. Both the jacket and cover may be either heated by steam or left without such heat. Special arrangements have been provided for the thermal elements to measure the temperature of the walls of the cylinder and cover. The plant is provided with jet and surface condensers, a wet pump and a pump for the cooling water being driven directly from the engine shafting. In order to increase artificially the area of the clearance space, the stroke was reduced from 761.5 mm. to 701.9 mm. and the space left free in this way was filled up either fully or partly with iron plates and perforated iron sheets, the total weight of which was so selected that in all cases there should be equal clearance on both sides of the piston: approximately 8.7 per cent. In this manner the area of the clearance space was divided into four stages, rising from approximately 0.404 qm. to 0.789 qm. (4.32 to 8.44 sq. ft.). Fig. B shows the arrangement of these additional elements and indicates that they are formed out of pieces of iron which are only slightly connected with

the other cylinder walls by means of supports having a very limited cross-section. In considering the number of these auxiliary areas in the heat exchange the masses of iron of which they are formed must also be taken into consideration. If O is the surface of one of such "free iron weights," independent of the walls, G is its weight and γ is the specific weight of iron, then

$$\delta = \frac{G}{O\gamma}$$

is the average thickness of O, i.e., the average depth which is available for the penetration of heat waves into the iron. In this case the value of δ is the same for all stages; viz., 0.6 mm. (0.024 in.)

In all tests, the admission pressure of the steam was maintained at 7.2 atmospheres gage; the pressure in the exhaust valve chest at about 0.15 atmospheres absolute, the admission at about 18 per cent and the speed at 92.5 r.p.m. The compression was varied in four stages, viz., 1, 12, 25 and 50 per cent and in order to maintain all other conditions equal, it was found advisable to vary the compression without interrupting the operation of the engine. Therefore in each case four tests of from two to three hours each were carried out with intervals of about one to two hours. Figs. C and D show the steam consumption per i.h.p-hr., with and without heating, as functions of the degree of compression. Other figures give the same steam consumption as a function of the compression end pressure as well as the steam consumption for the different degrees of compression as a function of the areas. In Figs. C and D each test is represented by three points, the upper point corresponding to the value derived from the measurement of the feedwater: the lower point, the value derived from measurement of the water of condensation and the inner line the arithmetical means of the two. Figs. C and D show that, under the conditions maintained during the test, the steam consumption was at its minimum at degrees of compression between 10 and 25 per cent. In the test where the lower steam consumption was obtained, the most favorable degree of compression approaches the upper limit, while in the test showing a higher steam consumption (without heating, large areas), the lower limit is approached. It appears from the other figures that the most favorable steam consumption in all the tests was obtained with the same final compression pressure, and was found at between 1 and 1.5 atmospheres absolute, but the curves obtained are so flat that it appears that deviations from the most favorable degree of compression or most favorable final compression pressure do not produce an economically important influence on the steam consumption. The most favorable steam consumption is approximately obtained at the pressure at which the final temperature of compression is equal to the temperature of the walls, but it appears that the heat exchange between the compression steam and the wall does not absolutely determine the influence of the degree of compression on the steam consumption. Further, the initial condensation, at least within the limits of degrees of compression which are actually used in practical operation, is practically independent of the degrees of compression which materially affect only the heat losses due to the clearances.

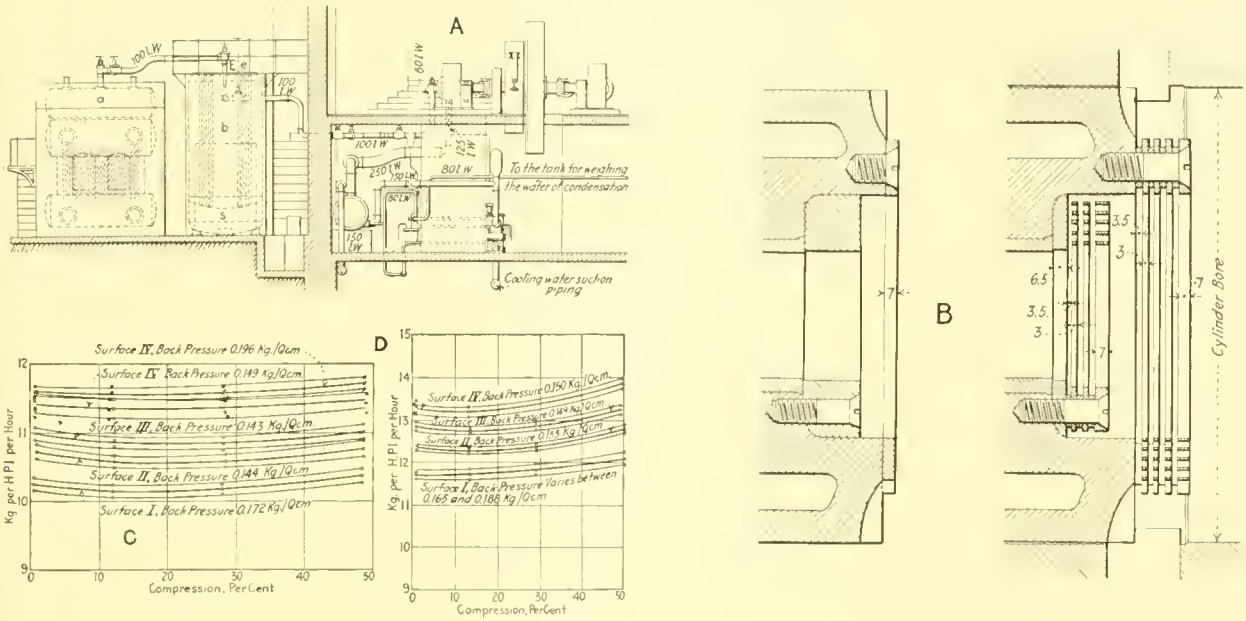

Fig. 6 Plant and Data of Tests on Heat Exchange in Steam Cylinders

The author made a purely analytical calculation of the shapes of the curves of steam consumption in connection with the degrees of compression based on the above statement under the assumption of different efficiencies, and obtained for efficiencies used in the test, curves which were in every respect similar to those obtained from actual tests. It appears therefore that the shape of the curves is determined by the quality. The most favorable degree of compression is reduced only when the quality becomes less, while higher degrees of compression have their most favorable values for higher qualities and tend to become unfavorable when the qualities become less. In engines of this kind (i.e. working with saturated steam and condensation), when the quality is known and the admission remains constant, an idea may be gained by simple calculation, sufficiently exact for practical purposes, as to the relation between the degree of compression, as well as the most favorable degree of compression.

The action of artificial surfaces, Fig. B, which provide an

average depth of wall material of about 0.6 mm. (0.023 in.) for the oscillation of the heat waves appears to be proportional to their dimensions both with respect to steam consumption and to initial condensation. Owing to the slight depth of oscillation which they offer to the motion of the heat in the wall, the action of these surfaces is slighter than that of the surfaces of the normal walls, in which latter is provided a possibility of unlimited permission of heat oscillation. The action of the surfaces for a wall thickness below a certain limit appears to be a function of that thickness. In the present case, in round numbers, it appears that the action of the additional surfaces is to the action of the original surfaces with respect to steam consumption, approximately as 1 : 3; with respect to initial condensation as 1 : 2. Calorimetric investigation shows the generally known differences in the processes of heat exchange with and without heating, the larger initial condensation, the smaller supply of heat during the period of expansion without heat as compared with what happens with the heating of the steam jacket. The other parts of this investigation will be reported after the appearance of the complete publication in the *Mitteilungen über Forschungsarbeiten.*

Loss of Heat by Locomotive Boilers through Cooling (*O potere teploty paravoznymi kotlami ot ocklajdeniya*, M. V. Gololobov. *Bulletin of the Permanent Committee of Advisory Conferences of Officers in Charge of Various Branches of Service on Russian Railroads* (in Russian), vol. 12, no. 12, p. 1013, December 1913 serial article, not finished). The amount of heat lost by locomotive boilers through surface cooling cannot be strictly determined from theoretical and physical data. The boiler presents a combination of several geometric bodies, each of considerable dimensions. It consists of a cylinder which ends at the rear by a parallelopiped with a round or flat top. On the cylindrical part there is a steam dome in front of which is located the smokestack and often the lantern. The rear part of the boiler (jacket) is often partly inside the cab. Finally the lower part of the furnace is located between the frames and has no lagging. The part of the outside shell of the firebox inside the cab on some railroads is not provided with lagging so that in the winter the men in the cab would not feel the cold. Even in the simplest case, when the boiler of a *locomotive at rest* is in stationary air, the elements of its surface will not be in entirely uniform conditions owing to the large dimensions of the boiler parts. The air particles heated by contact with the lower elements of the surface form rising currents, the temperatures and velocities of which increase gradually from bottom to top as long as the air remains in contact with the surfaces at higher temperature. The phenomenon will therefore be dissimilar for the same cylinder, in accordance as its axis is horizontal or vertical, and will be further dissimilar for flat, vertical or horizontal walls of the same surface. In physics, the action of the surfaces of large dimensions is but little investigated, although Ser in his *Cours de physique industrielle,* Vol. 1, Pp. 137-138, gives a formula for a sphere, vertical surfaces and cylinders with vertical and horizontal axes.

When the locomotive is in motion, the phenomenon is still more complicated by the fact that air currents flow along parts of the boiler following complicated trajectories which depend not only on the shape of the boiler, but also on its velocity, while behind the smokestack, steam dome and cab there are dead spaces, some of which screen one another. The surfaces within these dead spaces, or screened otherwise, will lose less heat since the air there is warmer through being subjected to less intensive exchange. A lateral wind complicates the situation still more, as on the whole, it would be expected to increase the cooling by blowing out the air from the dead spaces and reducing the screening effects. It appears thus that the problem of the cooling of a locomotive boiler in motion is a very complicated one.

From what has been stated above, three important conclusions may be drawn: First, the coefficient of cooling, i.e. the amount of heat lost per hour per square meter of boiler surface for the difference of temperature of 1 deg. cent., as determined from experiments on the cooling of boilers of small dimensions, is not fully applicable to locomotive boilers for which the coefficient must be determined by tests on locomotive boilers themselves. Second, if the coefficient of cooling be expressed by the formula $k = a + b\sqrt{v}$, where v is the velocity of motion, k for a stationary locomotive cannot be considered equal to k when $v = o$ (for instance to a), since k must be different and generally larger than a, owing to the fact that the air is never stationary when in contact with the walls of a stationary boiler. Third, the coefficient of the heat loss from the surface of a boiler is a variable quantity, so that one can consider only its average magnitudes not only for the entire boiler but for parts of it, uniformly screened and approximately under uniform conditions.

Owing to the complications introduced by these features, general methods of determining heat losses of a boiler in motion are of necessity extremely simple and rough. The inequality of the coefficient of cooling for the various parts of the boiler and its functional relation to the speed of motion are generally neglected, and sufficient attention is not paid to the selection of a proper numerical value for the coefficient of cooling.

The author proposes to review the experiments previously made for the determination of the coefficient of cooling of the boiler surfaces in accordance with the formula $k = a + b\sqrt{v}$ as the derivation of a most correct method of solving the problem of the cooling of the boiler with due regard to the various method of boiler lagging.

Forty-Third General Meeting of the Delegates and Engineers of the International Association of Boiler Inspection Societies (*Die 43. Delegierten- und Ingenieur-Versammlung des Internationalen Verbandes der Dampfkessel-Überwachungs-Vereine. Glückauf,* vol. 50, no. 3, p. 96, 4 pp. *g*). Only sections of possible interest to the American engineers are here reported. (*A*) *Report by Professor Blacher, of Riga, on Harmful Ingredients Contained in, or Added to, Boiler Feedwater, and on the Influence of the Working Pressure on the Action of the Said Ingredients.* The presence of carbon dioxide in the boiler feedwater cannot be considered objectionable as a rule, but where the process of corrosion of the boiler sheets has already started, it may accelerate it. It can, however, be easily removed by caustic soda. Air must be considered as a harmful agent, since the protective action of oxygen in boiler practice has been neither observed nor proved. The air in the presence of chlorides and under certain conditions causes dangerous spot corrosion, and since it is due to the action of the oxygen of the air mechanically carried into the boiler with the feedwater, it is advisable to take care to admit

as little as possible. It is very desirable to admit the feedwater either into the steam space or closely below the water level, so as to permit the air to escape into the steam. If there is a large amount of chlorides present in the water, it appears advisable to reject such water entirely, but if not, it is well to observe the inside of the boiler very carefully, and as soon as signs of corrosion appear, to install zinc plates in metallic connection with the boiler shell, taking care, however, to see that as little as possible of air is allowed to enter, since otherwise the oxygen will in a very short time destroy the zinc. As regards the *organic constituents*, Reischle, of Munich, discusses particularly the action of various tar, asphalt and graphite paints and mentions the Brun process, widely used in Switzerland, which consists in the addition to the boiler water of some linseed oil. On the whole, he comes to the following conclusions with respect to the use of means for preventing scale. They prevent more or less formation of scale but cannot be considered as a certain method of protection, with the exception perhaps of the above mentioned Brun process; they produce solution of old scale only occasionally, but usually make it brittle so that it either breaks off of itself or can be more easily removed. Sometimes their application may lead to overheating and injurious results to the boiler plates, especially the firebox plates, and finally they can produce clogging of the water level glass and blow-off cocks.

(*B*) *Report on the Causes of Bulging of Tubes in Water-tube Boilers even with a Small Deposit of Scale: can the influence of the shape of the firebox and adjoining heat passages be established in this connection?* The report of Chief Engineer Czernek, of Frankfort (Oder) states that formerly ruptures of water tubes were generally ascribed to poorly welded seams, but when seamless pipes came to be used, the number of ruptures did not decrease to the expected amount because, at the same time, the boilers were subjected to higher stresses owing to the introduction of superheats, and this became still more evident when, with the introduction of efficient chain grates and other systems of mechanical stoking, the temperatures in the firebox became considerably higher than those met with in hand fired plants. The places where ruptures of tubes frequently occurred were the first and second row of tubes, but nearly always in the part of the boiler surface subjected to heat radiation. The material used in the compilation of the report shows with nearly perfect uniformity that the causes of the rupture of tubes were unsuitable feedwater in connection with an unsuitable design of the firing space. If, for example, the firing space for the fuel in question is not built wide enough so that there is a second burning zone, due to eddy formation of gases in the neighborhood of the tubes owing to sharp changes of direction, there is always produced an over heating of the pipe walls. If at the same time unsuitable water is used, injury to the pipes becomes inevitable. On the other hand, where the firing space is properly designed and good feedwater, consisting mainly of oil-free water of condensation, is used, the pipes will remain in good condition after many years of strenuous work. Therefore, for the prevention of injury to the pipes, the following rules should be observed. Feedwater containing oil or organic substances should be avoided while the mineral substances should be removed by chemical means. The water must be brought to a high temperature in preheaters and the velocity of flow must be low. Nevertheless, if scale formation is observed, the boiler must be cleaned at short intervals, and especially after having been cold for a long time. Complete combustion of the fuel must be striven for; even with fuels rich in gases, the combustion must be completed in the firebox. To prevent the formation of long drawn out flame, additional air may be brought in at an angle to the direction of the flame. The fuel gases, when they leave the combustion chamber, must pass very close to the tubes and sharp changes of direction and all air supply at that point must be avoided.

Technical and Economic Experiences in Steam Turbine Operation (*Technische und wirtschaftliche Erfahrungen im Dampfturbinenbetrieb*, Professor Josse and K. Hoefer. *Zeits. für das gesamte Turbinenwesen*, vol. 10, nos. 33, 34, 35, 36, November 30, December 10, 20, 30, 1913. *s.A.* Conclusion of abstract begun in *The Journal*, February, 1914, p. 637). The article gives complete data, in the form of tables and curves, of steam consumption of turbines per kilowatt-hour. It points out that in various plants the experience has been that the steam consumption increases up to about 5 per cent during the first few years after the installation of the plant, although it worked under the same conditions of operation as before; partial renewal of the blading did not reduce the steam consumption to its initial level. The cause of this phenomenon could not be established. A very important question is that of steam consumption at partial load, since most of the time the power plant does not operate under its full load. The author quotes data for the steam consumption of various turbines at one-quarter, three-quarter and one-half load, and it appears that the large turbines are more economical at partial load than are the smaller turbines. In general, the turbines with a Curtis wheel appear to have a smaller specific increase of steam consumption at partial load than turbines not provided with such a wheel, due probably to the fact that in the first case, at partial load, some nozzles may be closed. It should be noted further that in some cases the steam consumption is lower at partial load than at full load: e.g., at three-quarter load it is 0.992 of that at full load. It appears that in this case the turbine has really been designed not for full load but for load somewhat below it, which would be correct since most of the time the turbine works not at full load but at partial load, and its design for the latter would therefore insure the most economical steam consumption. In addition, the vacuum in the condenser, owing to the small volume of steam at partial load, is improved, which in itself is favorable to the reduction of steam consumption. As regards heat consumption and thermal efficiency of turbine installation, it appears that, although single values obtained in different places differ materially from one another, with the increase of output of the plant there is a reduction in the heat consumption and an improvement in the thermal efficiency. The heat consumption varies from 10,000 WE. (39,700 B.t.u.) per kw-hr. in small plants to about 7200 WE. (34,580 B.t.u.) per kw-hr. in large plants while the thermal efficiency rises from 8.5 to 12 per cent. This is due mainly to the fact that in large turbines there is a small steam consumption. Further, in large installations the boiler and steam piping losses are also smaller, and that in the design of large plants, more attention is paid to, and more efficient devices are provided for, the best utilization of the heat produced. The thermal efficiency of various plants varies within wide limits, viz. from

5.73 to 13 per cent, and it appears that the time when the plant was put up has no influence on the heat consumption. Next to the steam consumption of the power plant, the first cost has the greatest influence on the economical results. The author gives exhaustive data on this matter in the form of details and curves from which it appears that the cost per kilowatt decreases with the increase of output from approximately 180 Marks ($43.20) per kw. for small outputs to about 70 Marks per kw. ($16.80) for outputs of about 6000 kw.

Tests of a Steam Water Heater in Counterflow and Parallel Flow (*Versuche an einem Dampf-Wasserwärmer im Gegen- und Gleichstrom*, A. Gramberg. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 5, p. 170. January 31, 1914. 8 pp., 13 figs. *e*). The article reports a series of tests on a water heater used in the machine laboratory of the Danzig Technical High School. It is built in such a manner that it can be used with both parallel flow and counterflow. The heater (Fig. 7A) consists chiefly of a copper heating serpentine coil enclosed in a jacket, the valve arrangement being such that while steam is admitted into the coil, water is at the same time admitted into the space surrounding it and by no error or carelessness can steam be admitted alone. During the test, these valves have been taken out in order to make the cross section entirely free. The main dimensions of the coil have been determined by careful measurements of the external dimensions and by weighing as follows:

Length of coil, m./ft.	4 22 / 13 83
Diameter, outer, mm./in	16 5 / 0 64
Diameter, inner, mm./in	14 1 / 0.54
Heating surface, outer, qm./sq. ft.	0 217 / 2.32
Heating surface, inner, qm./sq. ft.	0 185 / 1 98

The effectual external heating surface of the coil was assumed to be equal to 0.217 qm. (2.32 sq. ft.).

Fig. B shows how the heater is installed: The water may come in either through valve 1 from the city piping, or, if a particularly uniform pressure is required, through valve 2 from a special storage tank, and can be sent through the heater either from the top bottomwards or from the bottom upwards. In the first case, valves 3 and 5 are open and 4 and 6 are closed; in the second case, the reverse is done. The steam comes in in all cases from above and after passing through the water separator, is brought to the pressure at which it is to be introduced in the water heater. The water of condensation flows from the coil downward at *D*. When the water flows from the bottom upward, the heater works on the countercurrent principle; otherwise in parallel flow. This water heater has been used in the machine laboratory for establishing the conceptions of heat of liquid, heat contents of steam, the phenomenon of superheating of same at throttling; great losses of pressure in strongly cooled pipes and similar phenomena. All the important magnitudes may be measured. The water runs usually out at *W* through the funnel into the sink, but may be weighed by deflecting the funnel pipe. Two thermometers, t_1 and t, show the temperature of the incoming and outgoing water. The amount of steam may be determined by weighing the water of condensation which flows out at *D* and may be collected in a bucket. The temperature of the outgoing water of condensation is indicated by the thermometer t_c.

In April 1912, the author performed a series of tests described below, the purpose being to see the behavior of the heater at a given steam pressure, at a given temperature of outgoing heated water, at a given volume of water and finally at highest output, this highest output being characterized by the fact that the steam is put through in such

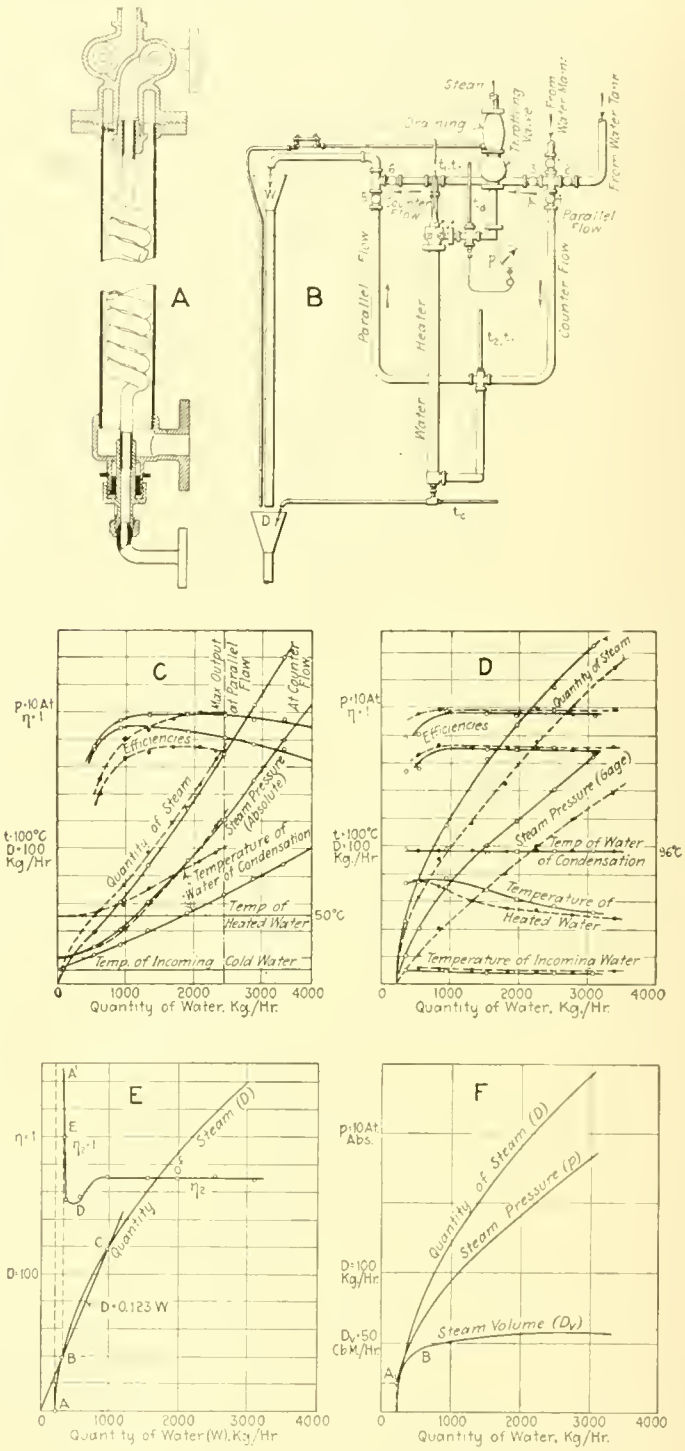

Fig. 7 Plant and Data of Tests on Steam Heated Water Heater in Parallel Flow and Counterflow

a manner as to bring the outgoing water of condensation near the boiling temperature.

Series 1: The volume of water was maintained constantly while its temperature, and therefore the exchange of heat, is varied. This was done by varying the steam pressure in

the heater. At moderate pressure, the steam does not penetrate far into the coil; it comes to a certain part of the coil only, while the rest of it remains filled with air, through which, along the walls of the coil, flows the water of condensation so that the pressure in the entire lower part of the coil is equal to one atmosphere. With increasing steam pressure, the steam penetrates farther and farther into the coil as shown by the rise of temperature of condensation due to the fact that the water of condensation, flowing through a shorter piece of the coil, has less chance to cool down below 100 deg. cent. (212 deg. fahr.). When the steam pressure rises, the amount of condensation increases as well as the temperature of the water of condensation. The steam pressures which the heater requires, due to the amounts of heat given up to the water, are quite considerable, and in the present series of tests, have gone up to 5 atmospheres, but with higher steam pressures, the steam breaks through without condensing. The temperature of the water condensation approaches 100 deg. cent. (212 deg. fahr.) and at still higher steam pressure, the entire steam is not condensed and part of it comes out from W. This means steam losses and a reduction of efficiency, and the highest output appears to be obtained when the temperature of the water of condensation is 100 deg. cent. (212 deg. fahr.). This maximum output is higher for the countercurrent arrangement than for parallel flow. A certain amount of water in the countercurrent arrangement is heated up to 69 deg. cent. (156.2 deg. fahr.) while with parallel flow, steam breaks through when the same amount of water is heated only up to 56.5 deg. cent. (133.7 deg. fahr.). The water circulation is therefore correspondingly smaller in the latter case. The efficiency of the countercurrent arrangement is also higher while the temperatures of the water of condensation which represent the heat losses are considerably higher at parallel flow than at counterflow.

Series 2: Behavior of the Apparatus when the Temperature of the Water is maintained at 50 Deg. Cent. (122 Deg. Fahr.). The amount of water is variable and the steam pressure is adjusted by the throttling valve in such a way that the water flowing toward the heater has the desired temperature. The results of the test are repeated in Fig. C, where the curves for the countercurrent arrangement are drawn in full lines and those for the parallel flow in dotted lines. In order to heat larger amounts of water, higher steam pressures are used (up to 10 atmospheres in the present series of tests) and the greater exchange of heat with increase of water means always that larger parts of the coil are filled with steam until finally the entire coil is filled with steam, when the temperature of water of condensation rises to 100 deg. cent. (212 deg. fahr.) and the point of highest output is reached. Comparison shows that for this case, the countercurrent arrangement is always superior to that with parallel flow. This difference in favor of countercurrent flow is especially noticeable at the highest output. At parallel flow in the present apparatus only 2450 kg. (5390 lb.) per hour could be heated up to the standard temperature, while with countercurrent and a higher steam pressure up to 3800 kg. (8360 lb.) per hour would be heated. As regards the shape of the curves, it may be noticed that the temperatures of condensation in one case converge toward the initial temperature of 11 deg. cent. (58.8 deg. fahr.), while with parallel flow they tend to converge toward the outflow temperature of 50 deg. cent. (122 deg. fahr.). The efficiencies are less favorable for small outputs because with uniform temperature of water, the heat losses are constant, and therefore affect a small output more than a large.

Series 3: Behavior with Definite Steam Pressure. When the steam pressure available is maintained at a constant level, say five atmospheres, but different amounts of water are taken out of the heater, the process occurred as represented in series of curves shown in the original article. When the amount of water taken out decreases, its temperature rises as well as the temperature of the water of condensation, flowing out of the apparatus, but the amount of heat exchange and steam introduced decreases. The water flowing through the heater may be reduced until the temperature of the water of condensation rises to 100 deg. cent. (212 deg. fahr.) and then the water reaches the highest temperature which the heater can produce, viz., a little over 50 deg. cent. (122 deg. fahr.) with parallel flow and approximately 70 deg. cent. (158 deg. fahr.) with counterflow.

Series 4: Highest Output of the Apparatus. The highest output of the apparatus is reached when the water of condensation leaves it with a temperature of 100 deg. cent. (212 deg. fahr.) and the steam is therefore just about to break through. For purposes of measurement one has to avoid this highest output, since at 100 deg. cent., notwithstanding careful lagging of the condensation bucket, considerable heat losses take place. For test purposes, therefore, the highest output is assumed to occur when the water of condensation has a temperature between 95 and 97 deg. cent. (203 to 206.6 deg. fahr.). At its highest output (compare Fig. D) the heater can heat the water to a temperature in inverse proportion to the amount of water flowing through it. The efficiencies for equal temperatures of the water of condensation are of course equal and appear to be less attractive for countercurrent flow than for parallel flow. With constantly decreasing amount of flow, the curves of efficiency assume a peculiar formation which, however, holds only for countercurrent flow. The curves of the steam volume and steam pressure in Fig. D converge toward the same point which appears to lie at a water output of about 150 kg. (330 lb.) per hour. The lower part of these curves cannot be obtained, however, since at the limited output of water (150 kg. or 330 lb. per hour) and at zero volume of steam, the water cannot be heated any more up to 75 deg. cent. (167 deg. fahr.), neither will the water of condensation leave the apparatus with a temperature of 96 deg. cent. (204.8 deg. fahr.). The efficiency curves will therefore asymptotically approach the line AA' in Fig. E or the efficiency must become equal to one previous to that. This happens at the point where the curve for the steam volume intersects with the straight line expressed by the equation $D = 0.123W$. From the rise of temperature of water by about 65 deg. cent. (149 deg. fahr.) and latent heat of steam as well as the consideration of the temperature of the water of condensation being 96 deg. cent. (204.8 deg. fahr.), it may be determined that for D equal to $0.123W$, the efficiency η_i is equal to 1. From the point of intersection B is determined, further, the point E to the left of which the temperature of water of condensation of 96 deg. cent. (204.8 deg. fahr.) can no more be secured. The curve of efficiencies η_i appears therefore to have the course shown in Fig. E, which indicates the reduction of temperature of water for outputs of less than 1000 kg. (2200 lb.) per hour. From the date indicated in Fig. D, some further

calculations may be made. From the weight of steam and the steam pressure, the steam volume entering into the heater can be calculated. This is shown in Fig. F, where it appears that at all pressures approximately 55 cbm. (say 1940 cu. ft.) per hour flow into the heater, and since the free width of the coil is 12.1 mm. this indicates a steam velocity of about 100 mm. (328 ft.) per second. This velocity is approximately equal for all steam pressures, but at the left hand of the diagram must approach zero, since under the above assumptions the pressure of the steam at the outlet of the coil has to be equal to atmospheric pressure. (It has been mentioned that the steam valve has been taken out of the water heater and that there were therefore no contractions.) The appearance of this curve is characteristic for the entire phenomenon. For flow without resistance, the velocity remains uniform up to a certain critical pressure ratio (entering flow pressure equals 1.8 of the back pressure and the velocity falls only at similar entering pressures). For flow with resistance in long piping or in steam turbines, the entering velocity remains constant up to a certain larger pressure ratio. In the present case, the reduction of pressure is not readily recognized and the critical pressure ratio may be estimated at approximately 3, corresponding to *B* in Fig. F. The velocity of inflow, although it could not be determined with absolute exactness on account of the uncertainty of temperature of superheat, is still around 100 m. (328 ft.) per sec. It remains therefore substantially below the velocity of sound in steam which at the gage pressures used in this case is somewhere between 460 and 490 m. per second (say 1500 to 1600 ft.). The velocity of sound is therefore not reached by far. The author investigates also the process of heat exchange in pipes and establishes the fact that with a large steam pressure, the pressure losses are considerable.

Strength of Materials and Materials of Construction

Application of Polarized Light to Problems of Applied Mechanics Dealing with Distribution of Stresses (*Les application de la lumière polarisée aux problèmes de la Distribution de l'effort en mécanique appliquée*, E. G. Coker. *Revue générale des Sciences*, vol. 24, no. 24, p. 918, December 30, 1913, 9 pp., 15 figs. etA). In the section "Engineering Societies" are mentioned the Cantor lectures of Prof. E. G. Coker, of London. The present article by the same author presents with considerable detail another method of determining the distribution of stresses in a body by means of polarized light. When a transparent body, such as glass, is subjected to strains, it acquires a double refraction. A sheaf of beams of light, the transversal vibration of which are in the same direction, is broken up into two components, one of which vibrates in the direction of the main maximum stress and the other in the direction of the main minimum stress. If, for example, the case is considered of a rectangular plate (Fig. 8A) subjected to the tensile stresses p and q, at right angles to one another, the state of tension through a plane section which passes through the point O of the plate may be represented by a vector of an ellipse in which the major axis OA is represented by p and the minor axis OB is represented by q. If the plane of vibration of the rays of light is COC', the effect of the system of stresses in the matter is expressed by the division of the rays of light into two components, one of which vibrates in the direction of OA and the other in the direction of OB. The two sheaves of rays do not travel through the plate at the same speed, and although all along the plate they are in phase with one another, they are not so at leaving the plate, and this difference of phase is maintained later on during their motion through the air. Therefore, if one interposes a prism or another device which has the power of selecting the component of each vibration with respect to a given plane, the influence of interference which produces a color sensation may be observed, the latter being particularly clear if the plane selected is at right angles to the plane COC'.

Fig. B gives a diagram of the apparatus used. Glass is not a convenient substance for this kind of test owing to its brittleness, but other transparent substances may be used instead, such as nitro-cellulose products which are consider-

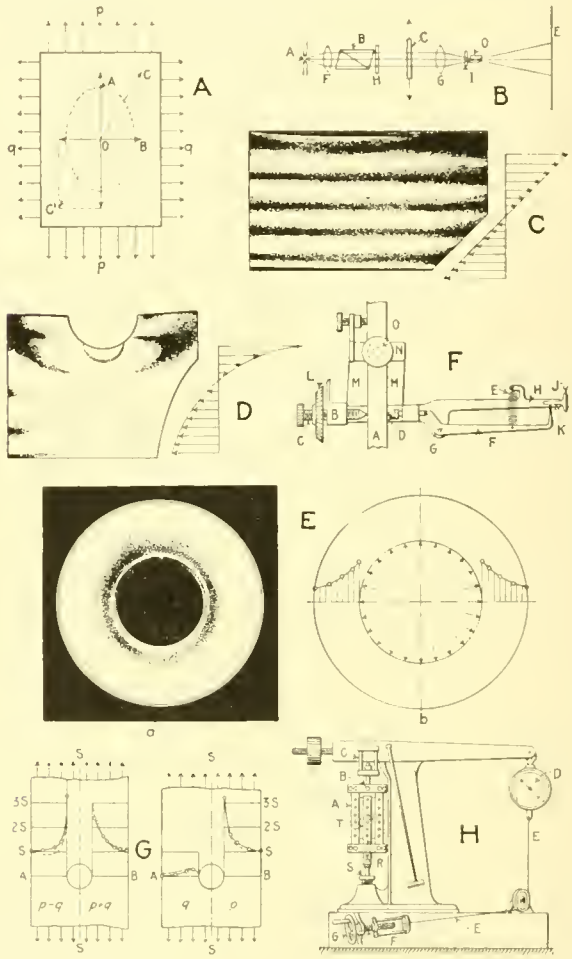

Fig. 8 Determination of Distribution of Stresses by the Polarized Light Method

ably more ductile. The author used a substance called xylonite. If a plate of such substance is placed in the optical apparatus in such a way that when the plate is not subjected to stress, no light is transmitted, a moderate tension produces a white-gray color; as the tension increases, the color passes by invisible gradations to lemon, yellow, purple, red, and finally a clearly defined blue. If the stress is increased further, the scale of coloration is repeated for practically each stage of stresses. In this way a scale of easily recognizable colorations is obtained showing the intensity of the strains in substances. For example, in single tension and compression, the relative lag of light rays which produces the color effect is proportional to the stress and

thickness of the plate; in this case the magnitude of the stress is determined by the appearance of the color bands, the fact that tension or compression produce similar effects if the substance can freely vary in thickness being borne in mind. If a transparent beam is subjected to a uniform moment of bending, a system of color bands is obtained, distributed as shown in Fig. C, and the distribution of stresses across the section can be determined as shown in the diagram at the right hand of the figure. One can see that the stress varies uniformly from the maximum compression on the inner surface to *O* at the center. There it changes sign and uniformly increases up to a maximum tension in the upper part of the beam exactly as in a metal beam subjected to the same kind of load. This is, by the way, one of the cases where the results of optical investigation can be compared not only with the mechanical measurements of strains but also with the theory of distribution of stresses in materials, and it is found that the values experimentally determined for transparent substances agree very well with the exact theory and the measurements of actual strains. One may, therefore, rest assured that in complicated cases, the stresses in a transparent model are the same as in metal elements. The author, as an example, considers the case of a notched beam, as shown in Fig. D, where optical investigation shows, as one might expect, that the influence of the notch is to increase considerably the stress in the substance. The distribution of stresses is now much more complicated than in a simple beam. The neutral axis is displaced toward the notch while the color effects show that the maximum stress is at least twice as large as in a beam without the notch. The color bands really are quantitative pictures of differences of principal stresses at each point, and, from this notion, several applications may be attempted in the field of mechanical engineering. Some of the most interesting of these applications are met with in investigation of curved bodies, such, for example, as pipes transmitting fluids under pressure. The action of water or another fluid may be imitated by applying to the pipe a uniformly distributed pressure by means of a conical mandrel, so that the pressure should be distributed as shown in Fig. *E*a which produces in the beam a perfectly symmetrical distribution of stresses. In this case, the color bands show that there is a large stress at the inner surface which diminishes at first rapidly and then gradually, towards the external surface. There is therefore a strain of radial compression accompanied by circumferential tension and the optical effects at that point are proportional to the algebraic difference of their intensities (in this case to their numerical sum). In a thick cylinder of the same proportions, the radial stress is not great, and its intensity may be determined independently, but their combined effect has been measured (see *E*b). The application of a fluid pressure, measurable at the cylindrical surface of a ring in such a manner that no essential part of it might escape observation, is also an interesting mechanical problem, solved by an assistant of the author in the following ingenious manner: A little pump, the piston of which is actuated by a screw, forces oil at the desired pressure into an annular space between two metal discs, riveted together in the center, and the fluid is sealed in by a retaining rim which prevents its losses. This rim projects slightly beyond the periphery of the disc and carries on it a transparent object submitted to the stress so that all of its parts are visible for the purpose of measurement. The same arrangement may be applied to the case of the thick pipe subjected to external pressure such as happens for example in boiler tubes. In a rim that is subjected to an extreme external pressure, the color bands are nearly exactly the same as in Fig. *E*a. The stress is maximum at the inner face while the law of variations of stresses is practically the same as that established experimentally and shown in *E*b; the only exception being that the sign is due here to the compression strain.

The author discusses in detail such complicated cases as substances having defects of structure, or having annular forms subjected to tensile stresses applied diametrally, as in chain links. He passes then to the determination of the principal stress.

The cases of distribution of stresses considered above are such that one of the principal stresses at the point is very much larger than the other, while in several cases the minimum stress is zero. If, on the contrary, both stresses have certain values, it becomes important to separate them and to determine their magnitudes. If p and q are the main stresses at the point, the coloration is proportional to $p - q$ and this difference may be measured either by direct observation or by simple mechanical means. The measurement of the sum of principal stresses at the point is obtained by making use of the fact that the stress produces a variation in the thickness of the substances proportional to the sum of $p + q$ and this difference may be measured either by direct observation or by simple mechanical means. If, for example, both stresses are tensions, there will be produced a lateral contraction equal to $(p + q)/mE$ where E is the direct modulus of elasticity, m the Poisson ratio. The two latter quantities may be determined and the sum of the stresses deduced if one has a sufficiently sensitive extensometer for measuring the lateral contraction. The values of mE differ considerably for various substances, but in the artificially transparent substances used in this investigation they are considerably less than in metals, and their determination is much easier. The best value of E for xylonite is 300,000 (with pounds and inches as units), while m is about 2.5, so that for each 1,000 lbs. of strain applied, the corresponding lateral contraction on plates ⅛ in. thick is 1/6000 in. To measure such a quantity satisfactorily to one or two per cent, it is necessary to use an instrument capable of indicating the variation of about 1-100 of this quantity, and the author and Mr. Scoble have constructed a lateral extensometer capable of detecting a variation of about one-half millionth of an inch. Fig. *F* shows the construction of this apparatus. The frame *B* carries a micrometer screw *C*, the point of which touches the plate of transparent substance. This plate is opposite to a second piece *D* the inner end of which is slightly pressed against the plate by the spring *E* while the other end bears against the short lever arm *F*, carefully pivoted at *G*, controlling the angular position of a lever *H* of a mirror *J* pivoted at *K*. Every change produced in the thickness of the sample between the points causes a rotation of the mirror and may be observed by following the motion of the luminous point reflected from the mirror in the usual manner. The observations may be controlled by a micrometer screw, which for this case is provided with a graduated head *L*. The

points only bear against the face of the plate without penetrating into it so that the value of thickness as determined is exact.

A combination of the two above described means, with the sum of the two quantities determined by one process and the difference by another, necessitates extreme care in the determination of the exact values of each quantity, especially if one of the quantities is much less than another, since even slight errors of observation form important percentages of error in the value of the smaller quantity. As an example of this method, the author gives the measurement of a piece with a central hole in tension Fig. G. The values of $p + q$ and $p - q$ at the minimum transverse section are indicated on one of the diagrams as functions of the stress s, on the part of the plate which is not cut, while the separate values are given by the second diagram. Then by dotted lines are indicated a series of values calculated by theoretical calculation. The agreement of the two sets of values is remarkable as the test was rather severe since in this section, the radial stress q is slight while the tensile stress p is large, but the optical measurements show in an exact manner the characteristic valuations of p and q as well as the fact that the stress q must disappear at the exterior edges of the plate.

The author discusses in detail the determination of lines of principal stresses and shows by examples how this is done. He passes then to the application of the optical process to the case of shear stresses. To apply uniform shear stress to a plate made of transparent substance, he constructed a frame consisting of a pair of flat steel bars, holding the two long edges of a xylonite plate and clamped from both above and below by small and equal horizontal bars. As shown in Fig. H, a rectangular frame A is suspended by pin B from a supporting frame C of a simple lever testing machine of the Buckton type, and a central pair of holding bars R attached to a lower hook S holds the plate in such a manner that the equal rectangular elements T on each side of the central line are subjected to uniformly applied shear stress. In order to apply and change this stress, a spring balance D carried on the external knife of the testing machine is actuated by the wire E which passes over a guide pulley on to the screw F where, by means of the hand wheel G, one may in a few seconds obtain the desired stress. Shear stress produced at a given point may be determined directly from the coloring effect produced, but it is more convenient and exact to apply the zero method by using a piece placed in tension independently along the line of the main compression stress and placing on that test piece a load until the production of a dark field. The relation between the tensile stress I in the calibrated test piece and the shear S, at a point of the plate, is easily deduced from the fact that the shear, pure and simple, is determined by the numerical value of one of the main stresses p at the point, or, since the other main stress is equal to $-p$, the optical effect produced corresponds to $2p$. The shear stress may therefore be determined by placing the calibrated test piece in tension with its axis in line with the main stress of compression and increasing the tension until the production of a dark field of maximum intensity. The stress of the test piece while in tension is then numerically equal to twice the shear stress S. The apparatus used for this purpose consists essentially of a miniature testing machine with a frame, shaped like L, clamped to a vertical bar and pivoted about a horizontal axis. The tension on the testing piece is produced by means of a spring balance, one end of which is connected to the main lever, while the other end is connected to the frame by an adjustable screw. The author gives several examples of the application of this method.

Concerning the Causes of Trouble from Fungus on Telegraph Poles (*Über die Ursachen der Hausschwammplage an den Telegraphen-Stangen*, Karl Havelik. *Zeits. für Schwachstromtechnik*. vol. 7, nos. 23 and 24, pp. 633 and 656, December 1913. 5 pp., *pt*). The author discusses the curious fact that while on the Austrian side of the frontier a large number of telegraph poles impregnated with copper sulphate are strongly attacked by fungus (Merulius lacrymans), considerably less of these phenomena are observed on the other side of the frontier, especially in Germany. After a careful investigation he observed that poles which are placed in the sidewalk have the longest life; further that separate poles live many times longer than poles combined into the A-structure, while the latter are less long lived than similar poles in an H-structure. When he investigated the causes of these facts he found that poles placed in the sidewalk are surrounded by closer trampled earth, which forms part of the sidewalk itself. In addition, the single pole is in itself a very unstable structure, and unless placed in hard ground would be rapidly drawn out of its vertical position by the strains produced in stringing the wires. Therefore the earth all around the pole has to be well pressed in. It has been found that such a pole being fully protected from moisture, sometimes has a usage of 30 to 40 years, and when drawn out of the ground its cross-section gives an impression of perfectly fresh wood. Such poles begin to rot from the top, and by the process of center rotting are sometimes destroyed in a quarter of a century, though this period may be shorter if the upper part of the pole has not been well enough impregnated. On the other hand, poles which have been placed in the road itself are never fully protected from moisture, especially in the lower part in the earth. Therefore they rapidly develop center rotting, and are destroyed in a much shorter time than similar poles placed in the sidewalk, their period of life being somewhere around 18 years. The type of pole which particularly attracts the attention of engineers in Austria in connection with the question of rot is the A-shape structure which is, as the author points out, in itself so stable that no particular necessity is felt for hard pressing in the ground around it. On that account the ground is generally loose and the pole is always surrounded by moist earth. This produces a tendency to rot which affects this type of pole in particular. In several instances where a telegraph line has been made up partly of single poles and partly of combined A-poles, it has been observed that after a few years the A-poles have to be exchanged once, then twice, while the single poles are still in perfectly good condition. Investigations have shown that the A-poles are attacked by real fungi, while the author has never been able to discover the appearance of real fungi on single poles. It has been further noticed that the spread of the fungi on telegraph poles is not as uniform as in house timber, probably because the conditions of temperature and moisture in the house are more

uniform. In the case of the telegraph pole there is particularly intense rot on certain places, especially near the surface, while at the surface proper the temperature and moisture variations are so considerable as to make life impossible to real fungi. It is interesting to note that sometimes the A-combined poles are not attacked by fungi. This happens mainly when the pole is under water and the water prevents the access of air necessary for the life of the fungus. The author estimates that about 30 per cent of all the A-shaped poles in Austria are placed in swampy ground, and by this fact are protected from the action of the fungus, and as a result have a much longer life than other poles. Further, if right around the pole there is a large growth of vegetation, the pole is protected to a certain extent from the appearance of the fungus which is then unable to destroy the entire part of the pole under ground. On the contrary poles which have no vegetation begin to rot very intensively at the depth of about 50 cm. (say 20 in.) and are destroyed within a period of two to five years. As a matter of fact the author appears to consider that the great trouble with the A-shaped pole in its relation to rot is its great stability which allows it to be placed in loose ground, often with a little heap of earth around. In locations where a heap of earth around the pole would not be tolerated on account of its being an obstruction to traffic, and where there is no place to throw the earth taken out of the ground, this earth has to be stamped hard into the hole, and a situation is created similar to that around a single pole. In such places the life of the A-pole is considerably longer than elsewhere.

Besides the single pole and the A-pole in Austria, there is also used the *H*-type pole, especially where the sum of the diameters of the wires stretched over it exceeds 100 mm. (4 in.). At first sight it would appear that such poles would be attacked by real fungus just as much as the *A*-poles, since their placing requires just as large holes. As a matter of fact, however, this construction is not so stable as the other, and besides the pole carries such a large weight of wires that it must be placed quite rigidly. Therefore the earth is stamped hard and the very care with which it is done acts as a guarantee in protecting the pole from the action of fungi.

The Austrian telegraph administration has applied with eminent success several materials of impregnation for telegraph poles, such as copper sulphate. It has also used stronger poisons such as sublimate, zinc fluoride, bellitsesquifluoride and fluopotassate of zinc chloride. Such poles impregnated with quick acting poisons have been placed in locations where the poles were attacked with particular rapidity, and have proved to be quite long lived and practically free from the attacks of the real fungus. As regards the prevention of internal rot the author recommends that the parts of poles impregnated with copper sulphate or zinc chloride be placed in either sublimate or zinc fluoride for several days submitting to this supplementary treatment such parts of the pole as will be later placed under ground.

Miscellanea

On Electric Conductivity of Gases and Steam Issuing from Steam Locomotive Smokestacks (*Sur la conductibilité des gaz et vapeurs émis par les locomotives à vapeur*, M. Parodi. Société internationale des électriciens, vol. 3, Ser. 3, no. 30, p. 1009, December 1913. 5 pp. *ep*). Many times, difficulties have been encountered in the operation of electric railroads using high-tension single-phase or three-phase currents simultaneously with steam locomotives. It has been found that mainly in tunnels and under bridges ruptures in insulators are produced, and arcs started between the lines and the supports of the insulators in the roof of the tunnel or bridge, even though the insulation has been designed on generous lines and has been tested at voltages three or four times above the normal voltage of the line.

Attempts have been made to explain this phenomenon by ascribing it to the action of deposits of soot and carbon on the insulators, but this explanation does not hold, since tests made by different engineers and repeated by the author, have shown that insulators covered on purpose by a thick layer of carbon deposits have proved to possess practically the same qualities as new clean insulators, both with respect to insulation proper, and to dielectric rigidity. It appears therefore that the cause of these difficulties on high-tension lines is to be sought in another direction and the author found that the starting of the arcs may be ascribed to reduction of the dielectric strength of the surrounding medium, due to ionization of the steam and gases issuing from the smokestacks of steam locomotives. As a matter of fact, the possibility of such ionization has been proved by the electrostatic machine of Armstrong which works on the principle of electrification by friction of moist steam escaping from a nozzle. In this machine a little boiler insulated from the earth generates steam and after passing through water lets it escape through a nozzle in a manner such that the steam strikes a conductor also insulated from the ground. The conductor is then charged positively while the boiler acquires a negative charge and with the pressure of steam of 8 to 9 atmospheres, long sparks may be drawn from the conductor practically without interruption. In the case of steam locomotives the phenomenon is somewhat dissimilar to that which takes place in the case of the Armstrong machine, since the locomotive is grounded, but the Armstrong experiment shows that gases and vapors coming out from the stacks of steam locomotives must be electrified and therefore act as conductors. To prove the presence of such ionization the author made direct experiments, measuring, on one hand, the charges transmitted by means of an electroscope and on the other hand measuring the distances of spark passages in the electrified gases. After the electroscopic tests experiments were made with locomotives with the steam up, but stationary, and the jet blower working. By varying the operation of the blower the composition of the gases coming out from the smokestack may be varied at will and a mixture containing more or less steam obtained. By placing the test plane of an electroscope over the smokestack of a steam locomotive it is found that it charges the electroscope in the usual manner and that the gases and steam which issue from the locomotive appear to be negatively charged. If the test plane is directly connected to the electroscope terminals, the electrification is so intense that the electroscope leaves are sometimes torn off.

Similar experiments have been made in order to determine the break-down voltage between plane and sphere at a constant distance from each other with the locomotive under them, and without, and it has been found that this voltage varies as follows:

	Breakdown Voltage (Volts	
	Locomotive under Spark	Locomotiv Removed
Blower closed	5544	9150
Blower half-open	4224	9150
Blower wide open	3960	9150

Since the output of the jet blower of the locomotive is only about one-tenth of the locomotive in working order the above figures indicate only the tendency of the phenomenon and not its actual intensity. They show, however, that the electrification of the air and the reduction of the breakdown voltage due to the ionization of the locomotive gases and steam are sufficient to explain the constant disturbances in the working of certain high-tension installations. Naturally, this phenomenon would be particularly noticeable in tunnels where the steam and gases of the locomotives accumulate in the upper part and form a sort of ionized cloud electrically connecting the walls of the tunnels with the high-tension conductors. In tunnels which are not properly ventilated and sometimes under bridges, this cloud disperses very slowly so that when an electrically drawn train comes through it, soon after the passage of a steam locomotive, an arc may start between the conductor and the ground even though the voltage used does not exceed the regular tension of the line. It may be roughly stated therefore that in order to avoid arcs in poorly ventilated places where steam and gases from locomotives may accumulate, the thickness of gaseous dielectrics must be at least two or three times as large as that used in places where ionized gases have no chance to accumulate. At the same time there are devices that will facilitate the elimination of the ionized gases, and ventilation especially will improve the installation of a high-tension electric line operated simultaneously with steam locomotives.

The author calls attention also to an easily observed fact which gives ocular evidence of the truth of his statement and which may be observed in the neighborhood of high-tension single-phase lines. Locomotive smoke in the neighborhood of the electric traction lines oscillates at a frequency equal to that of the line system. This phenomenon is often evident at night if the line is lighted by electric arc lights fed by current having also the frequency of the traction line. This synchronous vibration can be simply explained only by ascribing it to the ionizing action of the gases and smoke coming out from the stacks of the steam locomotives.

ENGINEERING SOCIETIES

AMERICAN CONCRETE INSTITUTE

Journal, vol. 1, no. 1, November 1913, Philadelphia

Report of Committee on Standard Specifications and Methods of Tests for Concrete Materials (Abstracted)

Effects of Electric Currents on Concrete, E. B. Ross, Burton McCullom and O. S. Peters

No. 2, December 1913

Effects of Electric Currents on Concrete, concluded

The Development of Concrete Grain Elevator Construction, R. P. Durham

Report of Committee on Standard Specifications and Methods of Tests for Concrete Materials (10 pp. *g*). Tests of the individual materials are not sufficient for determining the quality of the concrete made from them. A certain sand may give satisfactory results with one brand of cement and prove a failure with another. A sand of a certain granulometric composition may require an entirely different proportioning with one coarse aggregate than with another or may be unsuited for use with it because of the sizes of the grains.

Fine Aggregate. Sand or other fine aggregate should always be tested. In ordinary cases where special characteristics are not required, the test for acceptance is the determination of the strength of mortar made up with the cement and fine aggregate to be used on the work in comparison with the strength of identical specimens made with standard sand. The results of this test are also an aid to the selection of the proportions which should be adopted.

Compression tests of mortar are the most reliable, but tensile tests may be employed when a compression machine is not available.

Requirements for Strength. The aim in concrete construction should be to obtain a sand which produces a 1:3 mortar equal in strength to a similar mortar of a standard Ottawa sand. Sands producing mortars having a strength of less than 70 per cent of standard sand mortar should be rejected.

Between these two limits the variations in strength should be taken into account in fixing the proportions of the mortar or concrete.

The Committee sent out a circular letter of inquiry to various laboratories asking for information on various steps taken in testing cement, and from the answers received composed the following list. (Of course, not all laboratories use all methods):

1 *Examination of Deposit* to determine its uniformity, stratification, extent, overburden, methods of stripping, handling, screening, washing, etc.

2 *Preparation of Sample* to eliminate stone, water, silt, and to insure its being representative of the bank or the quantity from which it was taken.

3 *Tensile Test of Mortar* to determine the strength of known mixtures of the sand and portland cement at various ages and to compare this strength with that of standard Ottawa sand

4 *Compressive Test of Mortar* to determine the strength of known mixtures of the sand and portland cement at various ages and to ascertain what mixture is necessary to produce a required strength, or impermeability.

5 *Compressive Test of Concrete* to determine the strength of known mixtures of the sand and a coarse aggregate and portland cement at various ages and to ascertain what mixture is necessary to produce a required strength or impermeability. In the case of bank gravel or crushed stone which is not to be screened and reproportioned this test is used instead of No. 4.

6 *Percentage of Moisture* is determined in order to allow for the water contained in the sand in proportioning mixtures, computing freight rates, etc.

7 *Percentage of Voids* is determined:

a By determining the specific gravity of the solid particles and weighing a known volume of the sand and computing therefrom the percentage of voids.

b By filling the voids in a known volume of sand with a measured amount of a liquid.[1]

8 *Yield, or Volume of Mixtures* is determined by adding a known quantity of cement to a known quantity of the sand, wetting the mixture and noting the increase in the volume of the sand. This is repeated with various proportions of cement and sand to ascertain the amount of cement required to fill the voids in the sand.

[1] This method as usually practised is very inexact on account of the air entrained

9 *Density of Mortar and Concrete* is determined for various mixtures of cement and sand and of cement, sand and stone to ascertain that mixture which gives a material of the greatest weight per unit of volume.

10 *Specific Gravity of Solid Particles* is determined by three different methods:

a By the specific gravity apparatus, such as the Jackson flask.

b By pouring a known weight of sand into a known volume of water and noting increase of volume of liquid.

c For coarse aggregate by suspending pieces by a thread on chemical scales and noting weight in air and weight when hanging in a jar of water.

11 *Specific Gravity of Sand* including voids is determined by weighing a known volume of the sand exclusive of moisture and computing the specific gravity from the known weight of the same volume of water. Having determined the specific gravity of the solid particles (test No. 10) and also that of the sand (including voids) the percentage of voids in the sand may be calculated.

12 *Weight per Cubic Foot* is determined by weighing a known volume of the sand. This test is very closely related to test No. 11.

13 *Granulometric Analysis or Mechanical Analysis* is made by passing a known weight of the sand through a series of sieves of various sizes and noting the amount retained on each sieve and the amount passing the finest one. This test shows the distribntion of the particles from fine to coarse.

14 *Uniformity Coefficient* is determined from a curve plotted from the granulometric analysis by dividing the diameter of the particles at the point where the curve crosses the 60 per cent ordinate by the diameter of the particles at the point where the curve crosses the 10 per cent ordinate.

15 *Wet Screening* of a sand on the 100 and 200-mesh sieves shows the amount of fine material which can be washed from the sand and which in the case of dry screening in test No. 13 often adhere to the larger particles and so leads to uncertain results.

16 *Silt Suspended in Water* is determined by agitating a quantity of the sand with a large excess of water in a tall cylindrical glass vessel and noting the amount of silt which becomes suspended in the water and later settles down on the top of the sand.

17 *Silt Washed Out* is found by agitating a known quantity of the sand in water, allowing the coarse particles to settle and decanting or syphoning off the muddy water from the top. This operation is repeated until clear water is obtained. The amount of silt washed out is determined after evaporating the water.

18 *Loss on Ignition* is determined by heating to a red heat a weighed quantity of the dried sand and again weighing after cooling. This test is best performed only on the silt washed from a quantity of sand as the silt usually contains the injurious organic constituents of the sand.

19 *Organic Matter* is sometimes determined after the methods employed by the agricultural chemists.

20 *Chemical Analysis* is made to determine the character of the sand grains. Only a few of the most common rock constituents are usually determined quantitatively, for the purpose of judging of the strength and durability of concrete made from the sand. A high silica content is usually desired.

21 *Microscopical Examination* is made to ascertain the approximate size of the grains, their shape, character of surface and to detect the presence of objectionable material or foreign matter, such as mica or small roots or a coating on the grains.

22 *Absorption of Mortar and Concrete* made from the sand mixed in varying proportions with cement, or cement and stone, is determined to ascertain its suitability and the proper proportions for the production of a product having a minimum of absorption.

23 *Permeability of Mortar and Concrete* made from the sand is sometimes determined for various proportions of the constituents in order to determine mixtures for the production of an impermeable mortar or concrete.

24 *Effect of Different Cements* on some sands is quite variable and tests are sometimes made to determine with which of several available cements the sand will give best results.

25 *Freezing* during the setting time has a more injurious effect on mortar and concrete made with some sands than those made by others, and tests are made to determine the extent to which the sand is affected by freezing.

26 *Fire* has a more disastrous effect on some sands when used in mortar or concrete than it has upon others and a heat test is made to show the ability of the sand to resist fire.

ENGINEERING ASSOCIATION OF THE SOUTH

Journal, vol 24, no. 4, October, November and December 1913, Nashville

Methods and Costs of Drag-Line Excavation, James Allen Barr (Abstracted)

Development of Southern Assembly Grounds, Near Waynesville, N. C., J. W. Seaver, Jr.

Methods and Costs of Drag-Line Excavation, J. A. Barr (8 pp., 3 figs. *dh*). One of the first drag-line excavators was constructed by John W. Paige, who used a stiff-leg derrick and double-drum hoisting engines for lock work on the Sault Canal, at Sault St. Marie, Mich. In 1909-1910 the modern steel machine appeared, in which the chief improvement was the design of special engines adapted to the work instead of employing ordinary hoisting engines. The caterpillar traction, now an exclusive Bucyrus feature, was first applied by them to a gasolene drag line in 1912.

The drag-line Excavator is preëminently a machine for wasting or borrowing loose dirt. Especially where it is impossible to get cars close to a standard shovel or where a pit is under water or too wet, the drag line is the next machine to be considered. While the standard shovel is unequaled for close range work, still the drag line can do the same class of digging, but at a greater cost.

These machines can be used to dig sand and gravel under water where the depth is not too great by reaching out from the bank of the stream and moving ahead when necessary. This class also includes placer mining where the scale of operations or the initial investment precludes the installation of a regular dredge.

For digging ditches in drainage work the Class 9½ drag line is one of the best machines that can be used It is light and quick, and can be made to handle a large amount of dirt for its size For ditch work the machine should be provided with a caterpillar traction, which will give it a wide radius of action with a small moving cost. As long as the ground remains reasonably firm, rainy weather has no terrors for the drag line, the operator being protected

The drag line is successfully handling sand, clay, brick

shale, pipe clay, adobe, soft sandstone, bog iron ore, rotten limestone, powder-broken rock, or anything else that can be moved by a man with a pick and shovel. In Colorado a drag line wasted a rock cut that broke well upon shooting. In digging through a virgin forest in Arkansas a machine regularly pulled stumps after they were loosened with powder. The smaller ones, from 24 in. to 30 in., were dug around and then pulled directly.

OPERATING COSTS

Since the Class 14 is the average size used, its costs will be used for a general illustration.

One runner, $150 per month and board, for 25 shifts, including Sunday repair work	$6.00
One fireman	2.50
One team driver	1.75
One ground man	1.50
If machine runs on timbers instead of caterpillars, add one man.	
One foreman	3.00
One team (if owned by company)	3.00
Coal, 2 tons at $2.40	4.80
Cable wear	5.00
Repairs, supplies, oil, etc	3.00
Interest at 6 per cent	1.16
Depreciation at 10 per cent	3.50
Total cost per 10-hour shift	$35.21

If the machine could dig continuously, this would be 3½ cents per yard; but since it must move and occasionally lie idle, the average cost per job will be safely figured at 6 cents per yard under average conditions.

ENGINEERING SOCIETY, UNIVERSITY OF NEBRASKA

The Nebraska Blue-Print, vol. 13, no. 1, 1914, Lincoln

Calcium Hypochlorite Disinfection of Water, H. P. Letton
Test of York Ice Machine, C. L. Dean (Abstracted)
Paving, Pavements and Paving Materials, A. C. Smith
Essentials of Error Theory (*A*), L. B. Tuckerman, Jr.

TEST OF YORK ICE MACHINE, C. L. Dean (8 pp., 5 figs. *e*). The article gives complete data of a 69½ hours test of a York Ice Machine made in the College of Engineering of the University of Nebraska in 1913. For the detailed tables of data reference should be made to the original article.

The plant consists of two vertical single-acting ammonia compressors, 7½ in. bore by 10 in. stroke. The steam cylinder is of the horizontal type, having Corliss governor and valve gear, being 11½ in. bore by 10 in. stroke. The flywheel of this machine is 4 ft. in diameter and weighs 3000 lb. The ammonia condenser is of the double pipe style, the pipes being 1¼ in. and 2 in. diameter, each coil being ten pipes high and 18 ft. long. The freezing tank is of ¼ in. steel, 13¾ ft. long, 7 ft. wide and 4 ft. deep. It contains 35 freezing cans 8 in. by 15 in. by 35 in. of 100 lb. capacity. The brine coil consists of one section of double pipe, 2 in. and 3 in. in diameter, 6 double pipes high and 12 ft. long. The brine pump is a Duplex brass fitted pump 4½ in. by 3¾ in. by 4 in. An automatic thawing and dumping device is used for freeing the ice from the cans.

Thermometer wells are placed at all points where temperature is to be noted, and both steam and ammonia cylinders are fitted with reducing motions for the taking of indicator cards. A throttling calorimeter was used to determine the moisture in the steam, and Tabor indicators were used on all cylinders.

A meter registered all water used in jackets and ammonia condenser, the water from jackets being weighed as discharged, and this being taken from meter reading, gives water used in ammonia condenser. The condensed steam and condensing water was weighed directly.

The speed of both brine pump and engine was registered by attached counters. The amount of brine in the freezing tank was calculated from measurements and found to be 263 cu. ft. or 19,840 lb.

Temperatures were taken as follows: At suction pipe entering ammonia compressor; at each discharge pipe leaving ammonia compressor; ammonia entering condenser; ammonia leaving condenser and liquid receiver; ammonia entering expansion coil; ammonia leaving expansion coil; brine entering cooler; brine leaving cooler; room temperature; outside temperature; ammonia compressor jacket water, incoming; ammonia compressor jacket water, outgoing; ammonia condenser jacket water, incoming; ammonia condenser jacket water, outgoing; throttling calorimeter, upper and lower thermometers.

Following is tabulated the average data taken for each four hours of the test (lack of space will not permit the entire tabulation, and the results of the two parts of the test).

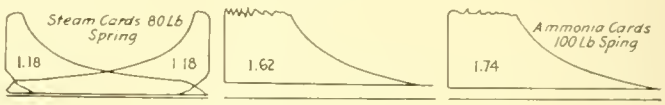

FIG. 9 INDICATOR DIAGRAMS FROM THE TEST OF A YORK ICE MACHINE

DATA AND CALCULATIONS, YORK MANUFACTURING COMPANY, 10-TON PLANT

Cylinder	Size, In.	Area Sq. In.	Diameter Rod, In.	Constant
Steam	11½ x 10	102.49	1⅞	0.00259
E. Compressor	7½ x10	44.18	1⅝	0.00111
W. Compressor	7½ x10	44.18	1⅝	0.00111

Cylinder	Length of Card, In.	Scale of Spring, Lb.
Steam	2.9	80
E. Compressor	3.00	100
W. Compressor	3.00	100

QUALITY OF STEAM

$$X = \frac{H - h + .48(t_2 - t_1)}{L}$$

H at 330 deg. = 1186.9
L at 330 deg. = 886.3
h at 212 deg. = 180

$$X = \frac{1186.9 - 180 + .48(272 - 212)}{886.3}$$

1.1 per cent moisture
Quality = 98.9 per cent

t_1 = temperature at atmospheric pressure
t_2 = temperature at lower thermometer

FIRST PART

Tank contains 263 cu. ft. brine
Density of brine = 1.207
Weight of brine = 263 × 1.207 × 62.5 = 19,840 lb.
Specific heat of brine = 0.8097
Temperature fall of brine = 64 deg. — 6.5 deg. = 57.5 deg. fahr.
19,840 × 0.8097 × 57.5 = 923,680 B.t.u. taken from brine
Allowing 3 lb. loss per can = 105 lb.
3790 + 105 = 3895 lb. ice
54 deg. — 32 deg. = 22 deg. temperature of water above freezing at beginning of test
3895 × 22 = 85,700 B.t.u. heat taken from water above freezing temperature
Latent heat of water = 142
3895 × 142 = 553,160 B.t.u. latent heat of fusion
Specific heat of ice = 0.504
32 deg. — 6.5 deg. = 25 deg. temperature of ice below freezing

3895 × .504 × 25.5 = 50,060 B.t.u. taken from ice
923,680
85,700
553,160
50,060

1,612,600 B.t.u. total
B.t.u. taken out per ton of refrigeration = 284,000

$\frac{1,612,600}{284000}$ = 5.60 tons refrigeration

Length of test 37½ hours

$\frac{5.68 \times 24}{37.5}$ = 3.63 tons refrigeration per day

Average h.p. = 9.04

$\frac{9.04}{2.63}$ = 2.49 h.p. per ton refrigeration

3895 lb. = 1.95 tons of ice

	Per Ton Refrigertion	Per I.H.P.H.	Per B.H.P.H.
Jacket water.....	607		
Ammonia condensing water.	13570		
Condensing steam, wet...	2915	48.8	63.4
Condensing steam, dry...	2880	48.3	62.7
Condensing water.....	50900	852	1108

During the second part of the test the cans were emptied and refilled as fast as frozen and the results here shown.

Total weight of ice made = 4643.6 lb.
Length of test = 32 hours
Average h.p. = 9.47
4643.6 lb. = tons of ice

	Per Ton Refrigertion	Per I.H.P.H.	Per B.H.P.H.
Jacket water.....	1355		
Ammonia condensing water.	17310		
Condensing steam, wet...	4175	42.7	55.6
Condensing steam, dry...	4130	42.2	55.6
Condensing water.....	73300	748	976

INSTITUTE OF MARINE ENGINEERS

Transactions, vol. 25, January 1914, Stratford

THE GYROSCOPE AND GYROSCOPIC ACTION IN ENGINEERING PRACTICE, Thomas R. Thomas. (Lecture delivered to the Institute on October 20, 1913. 40 pp., 10 figs. *gt*). The paper presents a general theory of the gyroscope and a discussion of some of its applications. In view of the fact that the theory of the gyroscope is fairly well known, only certain parts will be reported here. In discussing the application of gyroscopic action, both intentional and unvoluntary, the author calls attention to its occurrence in locomotive wheels when running around a sharp curve. In the case of an engine taking the right-hand curve, the front of the wheel would be moving to the right as compared with the center, and the bottom would consequently be forced in the same direction. This action is partly compensated for by keeping the outer rail higher than the inner, thus causing the weight to fall inwards; but the stress set on the axles must be appreciable. Another interesting example of gyroscopic action is found in the aeroplane—especially in one fitted with engines of the rotary type. Assume that the engine is of the Gnome type, rotating clockwise. If the rudder is put very sharply about, so as to bring the head of the machine around to the right, gyroscopic action forces the head downwards. If the pilot is expert and far enough from the ground, he can correct the effect of the dip, but on the other hand, if he is near the ground, he may be in considerable danger. On the Wright machines twin propellers are used, in this way correcting each other to a great extent, but not entirely, as they run in opposite directions. If the propellers were placed one behind the other, or one a tractor and the other a propeller, the compensation would be perfect. Further, it often happens that in a rotating wheel the center of gravity of the rotating mass is not in the center of rotation. A wheel may be perfectly machined and when tried in a lathe appear to be quite true, and yet when run at high speed it may run considerably out of true if the shaft is sufficiently flexible, which is due to the fact that the metal in the wheel is not homogeneous. The curious thing is that such a wheel when running at a certain speed, termed the critical, will become perfectly true, while at lower speed it will throw considerably. The author explains this phenomenon by gyroscopic action. In Fig. 10A a wheel fixed on a flexible spindle and running in bearings *BB* is shown. It is assumed that the spindle is uniform in action throughout. The wheel is exactly central between the bearings and the center of gravity is at *A*, a little away from the axis of rotation but exactly equidistant from the bearings. When the wheel is rotating, centrifugal force would bend the spindle until it took the form shown by the dotted lines. The wheel would be out of true radially, but quite true sidewise, with the eccentricity tending to increase with increase of speed, opposed only by the rigidity of the spindle. In actual practice such conditions would occur only rarely, if ever; more likely it would be found either that *A* is not exactly equidistant between the bearings or that the shaft is not uniform in section on both sides of the wheel. Suppose, then, a wheel mounted as shown in Fig. 10B with *A* in the same position radially as in the previous case but not equidistant between the bearings; then the wheel would not only throw radially but would also be inclined toward the original axis as shown by the dotted lines. With the wheel rotating, the top away from the spectator, gyroscopic action would force the part of the wheel nearest to the left, and then the top would be forced to the left. As this action is occurring all around the wheel, the spindle is set vibrating with a period equal to the time of revolution. The wheel will oscillate sidewise, or precess in the manner of a spinning top, but the precession will not be free unless the revolutions coincide with the actual period of vibration of the shaft. When they do, the wheel will at once spin true. If the time of revolution does not coincide with the period of the shaft there will be periods of wobbling when they are not in phase, and periods of stillness when they are. Precession will be retarded in the first case and accelerated in the latter. The author discusses also gyroscopic movements of a flywheel when inclined from the plane of rotation.

In the discussion which followed, Mr. E. Kilburn Scott mentioned that some 20 years ago a company for whom he worked supplied some ship lighting sets of electrical machinery, which, to economize space, were fixed with their axles *across* the ship; but it was found that the shafts were very liable to breakage when in this position owing to the gyroscopic action combined with the rolling of the ship. The difficulty was removed when the sets were placed with the shafts in a fore and aft position. Most gyroscopes in practical use run at about the same peripheral speed as that adopted by Mr. Brennan who, on his monorail car, used a wheel 4 in. wide and 3 ft. 6 in. in diameter, running at 3000 r.p.m., with the peripheral speed of about 33,000 ft. per sec.

The particulars of the various gyroscopes are given in Table 1.

The Anschutz wheel has been tested to destruction and

TABLE 1 DATA RESPECTING VARIOUS TYPES OF GYROSCOPIC WHEELS

	Used for	Diameter of Wheel, In.	Width of Wheel, In.	Speed, R.P.M.	Peripheral Speed, Ft. per Min.	Approx. Weight Wheel in Lb.	Material of Wheel	Type of Motor
Brennan	Monorail model	6½	2	2000	3400	7	Gun-metal	Direct current
Brennan	Large monorail car	42	4	3000	33000	1500	Nickel steel	Two direct current motors on each shaft
Anschutz	Compass	6	1	21000	32800	9	Nickel steel	Three-phase motor inside rim
Sperry	Compass	12	2	8600	27000	43	Vanadium steel	Three-phase motor inside rim

neither the rim nor the web have given way; it was the shaft that broke first. The peripheral speed of about 66,000 was obtained, calculated to equal 750 miles an hour, and yet the steel in the rim did not break. The spindle of the Anschutz gyrowheel is on the principle of the De Laval turbine—very small in diameter so that the wheel can find its own center of gyration. The shafts of the Brennan and Sperry wheels are stiffly built and everything depends upon the most accurate balancing. Mr. J. W. Gordon distinguished between a gyroscope and a gyrostat: calling the former the spinning member, and the latter, both spinning member and mounting frame. This distinction is of importance because the frame has the same properties as the gyroscope, being

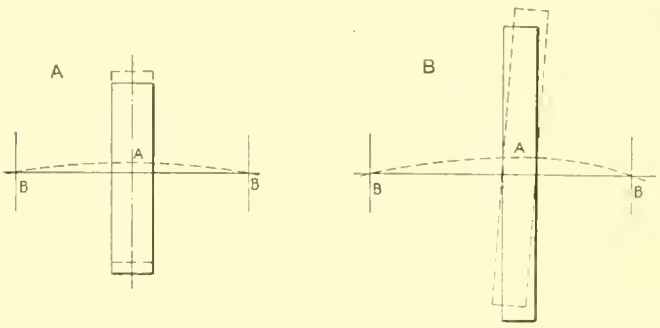

Fig. 10 Gyroscopic Action on a Wheel Having the Center of Gravity Not in the Center of Rotation

connected to the wheel in a manner such that it has to share in all the motions of the wheel except the spinning motion. The gyrostat therefore possesses all the properties in precession of the gyroscope, but there is one very important distinction between the two: The gyrostat has special properties in reference to what the author calls constrained precession, which may occur when the center about which one precession takes place coincides with the center of gravity, whereas the center about which the other precession takes place is at a distance from the center of gravity.

INSTITUTION OF MECHANICAL ENGINEERS

Advance publication, C, read January 16, 1914, London

Commercial Tests of Internal-Combustion Engines, W. A. Tookey (19 pp., 6 figs. *epA*). The paper describes methods of commercial tests of internal-combustion engines based on the experience of the author, who, during the past few years, made tests on over 700 gas engines of various sizes and makes. The author worked out the test sheet shown in Table 2. His experience with internal-combustion engines has indicated that the strength of mixture, although one of the most important matters which should be determined in all tests, is seldom taken into account in trials. In a former article (*Engineering*, October 15, 1909) he showed that the influence of mixture strength upon the thermal efficiency of internal-combustion engines was at least of equal importance with the compression ratio. He believes that equal thermal efficiency can be obtained through a wide range of compression pressures and from varying mixture strengths, providing the admission is properly correlated: by increasing the mixture strength, and delaying the firing point, higher mean pressures can be obtained with little, if any, loss of efficiency within certain limits.

Throughout the series of commercial tests, the author computed the mixture strength of the charges taken in by various engines in terms of total cylinder contents, that is to say, gas, air and residuals, and then comparing with the mean pressure (positive loop) calculated from intersecting diagrams. The factor, *mean pressure* mixture strength, has been of invaluable aid in deciding the steps to be taken to obtain better results from all the engines inspected. In order to express the mixture strength in terms of total cylinder volume, it is necessary to note the clearance volume as well as the piston displacement. The latter can be calculated from the cylinder dimensions of an engine, but the former, in commercial tests, cannot be definitely measured, although a close determination can be obtained by observing the compression pressure attained, and also by noting the volumetric efficiency of the engine.

The author describes in detail how he obtained all the data tabulated in the above table. He points out among other things that the compression curve exponent 1.30 appears to hold good for gas, gasolene, and oil engines varying widely in design within close limits, so that it appears probable that computations based upon the exponent 1.30 give sufficiently accurate data for ordinary commercial testing purposes. As regards the question of the weight of the mixture, he points out that, for commercial purposes, the internal-combustion engineer has no need of it, and if he can obtain information as to the relative mixture strength in B.t.u per cubic foot of effective cylinder volume it will be sufficient. But in the absence of knowledge as to the mixture strength used, he is absolutely in the dark and has to face the confusing situation that with one engine of a certain size coming on to the testing bed, the rated power, or consumption, may be readily obtained, while with perhaps another engine of the same or a different batch, he finds it extremely difficult to obtain the "list" figures for output or for efficiency. Without a knowledge of the mixture strength with which the engine is working and at which the engine works best, he cannot be certain that the test-bed adjustments are final.

The author points out that very efficient cooling and care-

ful adjusting of ignition-timing devices are required when the engines are called upon to deal with loads necessitating a continuity of explosions, producing mean pressures of the order of 90 lb. per sq. in., such high pressures being by no means uncommon in everyday work. The author believes that there is little doubt that gas engines rated by the makers upon the basis of 80 lb. per sq. in. for continuous work actually possess considerable reserve of power. However, the

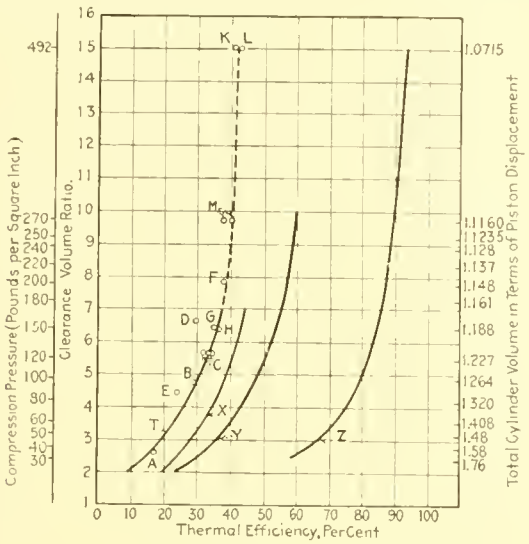

FIG. 11 CURVES OF TESTS OF INTERNAL COMBUSTION ENGINES

THERMAL EFFICIENCY, PER CENT

Z Increasing efficiency with increasing compression pressure due, by reason of reduction in clearance volume, to lesser total quantity of heat required to maintain equivalent mixture strength.

Y Air standard efficiencies on basis of constant specific heat (Institution of Civil Engineers Committee, 1905).

X Clerk's corrected efficiencies on basis of varying specific heat (Junior Institution of Engineers, Canet Lecture, 1913).

T Tookey's curve of practical efficiencies ($Z \times X = T$).

The circles and dotted continuation of curve *T* show the actual efficiencies obtained by various experimenters during thirty years (1881 to 1911), as accompanying table, and their close agreement with Tookey's curve.

Reference Letter	Test by	Maker of Engine	Date	Size of Engine, B.H.P.
A	Slaby	Otto	1881	4 5
B	Humphrey	Crossley	1900	360
C	Inst. C. E.	National	1905	*L*, *R*, and *X* engines
D	Stead	National	1911	750
E	Clerk	Crossley	1894	12
F	Burstall	Crossley	1904	50
G	Atkinson	Crossley	1905	40
H	Hopkinson	Crossley	1908	40
K	Longridge	Diesel	1905	500
L	Longridge	Diesel	1905	80
M	Robinson	Ruston	1910	50

manner in which engines can be run at these other loads is very rarely understood by men in whose charge they are placed. While until recent years no appliances were provided, by means of which the necessary adjustments could be made to obtain this much to be desired end, the only limit to an engine's capacity for overloads within the above mentioned range is the liability of preignition of the charge during the final portion of the compression stroke. The more nearly the temperature reaches a certain critical point, either by heat generated during the combustion or by cylinder wall radiation, the more nearly probable appear the higher efficiencies. The output of power depends upon the mixture strength; the richer the mixture, the more powerful the impulse in terms of mean pressure; but if the load demands a mixture so rich that the combustion when once started proceeds with extreme rapidity under the temperature due to compression and wall radiation, then preignitions are set up spontaneously, producing violent bumping and quickly bringing the engine to a standstill It is for this reason that engines governed by the "hit and miss" system can be worked continuously at high mean pressures without giving trouble; even if but one miss occurs at intervals of, say, 20 cycles, the engine will work quite satisfactorily, probably due to the fact that the air admitted during the miss, instead of creating turbulency, very effectually cools the skin of the internal wall below the critical temperature, which water circulation alone is unable to reduce. On the other hand, in throttle governed engines, preignitions are much more likely to give trouble since under heavy loads the compression pressure and temperatures are high and more heat is given to the walls.

Prior to the discussion, the author explained a chart shown in Fig. 11, which he had prepared to bring out certain points in relation to mixture strength. This chart and the following passages were not published with the advance copy of the paper, but were reported from the London *Engineer* of January 22, 1914, Page 108. The horizontal lines refer to clearance volume pressures; the vertical lines show thermal efficiency in percentage. The chart showed the variations which different authorities said were to be expected from any internal-combustion engine in terms of compression pressure, or, what amounted to the same thing, compression-volume ratio. The curve *Y* was that referred to by the Research Committee of the Institution of Civil Engineers in their report in 1905 on the basis of a constant specific heat. It had been promised that as compression pressure went up, higher thermal efficiencies would be obtained, but practice did not bear out that theory. Dugald Clerk had, among others, set to work to find out why that was not so. The curve *X* was taken from Dr. Clerk's figures, allowing for variation in the specific heat of the working fluid of internal-combustion engines. The curve was much nearer the *Y* curve at ratio 2 than at ratio 7, showing that, on going higher, the varying specific heat of the working fluid tended to make the engine become less efficient.

Another curve *T* is shown and along it are certain dots. The lower part of the curve (marked in full) has been calculated; the upper part has been elongated and drawn out to make it agree with the test representing the actual efficiencies that had been obtained during the last 30 years by different experimenters with internal-combustion engines of varying compression ratios.

JUNIOR INSTITUTION OF ENGINEERS

Journal and Record of Transactions, vol. 24, pt. 4, January 1914, London

Engineering Business, J. H. Rosenthal

The Future of Oil Fuel, Sir Roverton Redwood (Abstracted)

THE FUTURE OF OIL FUEL, Sir Roverton Redwood (34 pp., 1 fig. *gs*). This paper was delivered as a presidential address to the Junior Institution of Engineers by the author, who is well known as one of the great authorities on oil fuels.

After discussing the various uses of oil fuel and sources of supply, the author passes to the future of oil fuel and expresses a belief that it depends not only upon the extent to which the output may be reasonably expected to increase, but largely upon the manner in which the fuel is to be used, since in the light of our present knowledge the supply of oil fuel cannot be expected to increase to such an extent as to give consumers in general a free choice in substituting oil for coal as a source of power for industrial purposes, especially if the oil is not used in the most economical manner. The petroleum industry is unquestionably capable of much greater expansion. The use of oil fuel will undoubtedly largely increase. But it is evident that with all the rich new fields that may be expected to be developed, it will require a very considerable expenditure of capital directly to increase the average rate of expansion of the petroleum industry, especially in view of the fact that some of the older oil fields are showing signs of exhaustion. So far as the future can be at all predicted, there will doubtless be a large and continuous increase in the requirements of the navies of the world; as this demand is not primarily governed by price, it may be described as "irresistibly preferential" in character, taking precedence therefore over all industrial needs. Further, rapid progress may be expected in the use of more volatile products in road motor vehicles and in some countries there will doubtless be a greatly extended employment of oil fuel on the railways. Considered, however, as a source of power generally, it is improbable that the oil will be used otherwise than in an engine of Diesel or semi-Diesel type. As regards the use of oil as a source of power outside of the war navies of the world, it is evident that it must depend upon the price at which the fuel can be obtained. When the market value of oil fuel becomes established on what may be termed the Diesel engine basis, it is only those who occupy exceptionally favorable geographical positions with respect to the source of supply who could employ that sort of fuel in steam raising.

TABLE 2 MR. TOOKEY'S FORM FOR TABULATING DATA OF COMMERCIAL TESTS OF INTERNAL-COMBUSTION ENGINES

Test No. 595A — Date: 13 Feb. 1913
Name: S. & Co. — 2 Meters: 300 lt. No. 906089
Address: Bermondsey, S. E. — 300 lt. No. 37388
Assistant's Initials: A. R. P.
Machinery driven: Dynamo and cocoa-grinding plant.
24″ × 30″ (———) Gas Engine No. 10841.

R.p.m. { Light: 155
Load: 154

Specific piston displacement $\left(\frac{A. \times S.}{1728}\right)$ = 7 854 cu. ft. per stroke

Governor: Hit-and-miss

I.h.p. constant $\left(\frac{A \times S.}{396{,}000}\right)$ = 0 03427

Ignition: Two magnetos (low tension)

Piston positions from edge of liner—in-center: 23 375″ in; out-center: 6.625″ out = 30″ stroke

Exhaust valve setting { Open; piston 1″ out; lead 5 625″
Close: piston 14.5″ in; lag 8 875″

Mixture valve setting { Open; piston 22.75″ in; lead 0 625″
Close; piston 3 875″ out; lag 2 75″

Gas valve setting { Open; piston 20 5″ in; lag 2.875″
Close; piston 6 25″ out; early 0.375″

Compression pressure: 120 lb.

Compression pressure ratio $\left(\frac{C. P. + 15}{15}\right)$ = 9.0

Volumetric efficiency: 0 876

Effective piston displacement: (Spec. P. D. × V. E.) = 6.88

Clearance volume ratio $\left(\frac{1.8}{\sqrt{C. P. ratio}}\right)$ = 5.4

Clearance volume $\left(\frac{E. P. D.}{C. V. R. - 1}\right)$ = 1 563 cu. ft.

Charge volume: 8 443 cu. ft.

Improvements obtained: power per impulse, 9 per cent; consumption, 10 per cent.

In conclusion, the author vigorously pleads for economy in the production of petroleum and calls attention to the fact that immense sums have been thrown away in haphazard drilling operations while valuable oil fields have been destroyed by reckless procedure.

ROYAL SOCIETY OF ARTS

Journal, vol. 62, nos. 3189, 3190, 3191, January 2, 9 and 16, 1914, London

THE MEASUREMENT OF STRESSES IN MATERIALS AND STRUCTURES, E. J. Coker (30 pp. 41 figs. *dtA*). A somewhat popular, but very interesting presentation of the main problems and methods of measurement of stresses in materials and structures, forming the subject of three Cantor lectures delivered by the author in December 1913. The part referring to the optical methods of measuring stresses is reported in the Foreign Review section, from an article by the same author appearing in another publication.

PERSONAL NOTES

John E. Sweet, Honorary Member and Past-President of the Society, was given the degree of Doctor of Engineering at the midwinter meeting of the board of trustees of Syracuse University. Following this, at a meeting of the Technology Club of Syracuse, resolutions were adopted expressing the appreciative feeling of the local engineers, which fittingly represents also the views of the larger circle of engineers throughout this country and abroad, who are numbered among his friends:

Whereas, a member of this Club, eminently distinguished and of international fame in his profession, on the 10th day of January, 1914, received from Syracuse University the honorary degree of Doctor of Engineering, and

Whereas, said member is held in high esteem and affectionate regard, making this mark of distinction a matter of warm approval and personal gratification to every member, now therefore,

Be it Resolved, that the Technology Club of Syracuse, convened in regular session this 9th day of February, 1914, offer heartiest congratulations to its charter member, honorary member, and first president, John Edson Sweet, upon this academic acknowledgment and approval of his worth as an engineer, an educator and a man, and permanently record its pride in the possession of his inspiring personality, valued helpfulness, and, best of all, his constant friendship.

Prof. F. R. Hutton, Honorary Secretary, left on February 14 for Southern California to attend the Santa Monica races, where he will represent the Automobile Club of America. On his return journey he will endeavor to visit some of the Student Branches of the Society, as Chairman of the Committee on Student Branches.

Lewis D. Freeman has resigned as chief draftsman of the Kansas City Southern Railway Company, Pittsburg, Kan., to accept the position of mechanical inspector of the Seaboard Air Line Railway, with headquarters at Portsmouth, Va.

Robert A. Wilson has accepted a position as master mechanic of the Producers Oil Company, Houston, Tex. He was formerly connected with the Ohio Works of the Carnegie Steel Company, Youngstown, Ohio.

Perry J. Freeman has left the service of the Gullett Cotton Gin Company, Amite, La., and is now connected with the Kansas State Agricultural College, Kanhattan, Kan., as instructor in charge of applied mechanics and hydraulics laboratory.

Prof. A. R. Acheson, head of the department of mechanical engineering of Syracuse University, has been appointed consulting engineer for the Bureau of Gas and Electricity of Syracuse. Professor Acheson will not sever his connections with the University, but will devote only part of his time to the work of the bureau.

Wilbur N. Sar Vant has severed his connection as assistant engineer with the American Process Company, New York, to accept the position of mechanical engineer of the Hunsicker Engineering Company, Lebanon, Pa.

STUDENT BRANCHES

CARNEGIE INSTITUTE OF TECHNOLOGY

A meeting of the Student Branch of the Carnegie Institute of Technology was held on January 14. The paper of the evening, Hydraulic Forging Presses, was presented by Mr. Noble of the class of 1909, who described the construction, operation and relative merits of the more representative types of hydraulic forging presses being built in this country and Europe, and pointed out the advantages to be derived by the use of hydraulic presses instead of steam hammers. The paper was illustrated by lantern slides.

CASE SCHOOL OF APPLIED SCIENCE

Willard Beahan, first assistant engineer of the Lake Shore Railroad, presented a paper on the Engineering of Men at the meeting of the Case School of Applied Science on February 5.

KANSAS STATE AGRICULTURAL COLLEGE

At the meeting of the Council on February 13, permission was granted for the formation of a Student Branch at the Kansas State Agricultural College.

LEHIGH UNIVERSITY

On February 10 the Lehigh Mechanical Engineering Society held a meeting at which papers were presented on the Diesel Motor, by George F. Nordenholt (Student 1914), giving the history of the motor and describing some installations he had seen while abroad; and on Heating and Ventilating, by R. L. Spencer of the mechanical engineering department, developing several formulae on the subject and showing their use.

POLYTECHNIC INSTITUTE OF BROOKLYN

The monthly meeting of the Polytechnic Institute of Brooklyn Student Branch was held on February 7, the subject for discussion being the features of the inspection trip recently made to Schenectady, Buffalo, Niagara, Scranton and Wilkes-Barre. Impressions of the power plant of the Rensselaer night boat were given by Frederick Hohngreen, of the American Locomotive Works by Merritt Van Valkenburgh, of the hydroelectric plant of Niagara by George A. Wieber, of the Carborundum Works and the Shredded Wheat Biscuit Company by David Bonavety, of the General Electric Works by Paul Newman, and of the coal mines of Scranton by George A. Mebor.

UNIVERSITY OF CALIFORNIA

At the meeting of the Student Branch of the University of California on January 27, an illustrated lecture was given by Bert Barr on the Machinery of the Panama Canal.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch was addressed at its meeting of January 20 by Parker H. Kemble on the Construction of the Brooklyn Subway. The important difficulties incident to the construction were discussed and the methods of their attack briefly outlined. Slides showing views of the work during the different stages of development and of novel "hitch-ups" were used to supplement the lecture.

UNIVERSITY OF KANSAS

On January 22 the Student Branch of the University of Kansas, Prof. A. J. Boniton of the economics department gave an address on Recent Industrial Legislation, in which he discussed at some length the new system of banking, explaining the need, its organization, method of operation and its probable effect on business. While somewhat out of the engineering field, the address created much discussion and aroused the interest of the members.

UNIVERSITY OF NEBRASKA

The Student Branch of the University of Nebraska held a meeting on February 3 at which Prof. P. K. Slaymaker gave a talk on the Manufacture of Iron in which he briefly

described the character and value of the ores and where they are mined. He outlined some of the many difficulties experienced in designing a good working furnace and showed the general layout of a blast furnace plant with the ore handling apparatus.

YALE UNIVERSITY

At the meeting of the Yale Student Branch on December 16, Frank Gilbreth gave a talk on how to obtain least waste and minimum movement of operator for each operation, which was illustrated by lantern slides.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

1210. Sales engineers; applications invited from young men 30 to 35 years old who have had thorough machine-shop training, preferably in tool making, design, and with some experience in selling; technical education preferred.

112 Senior draftsman, three or fours years' experience in the design and supervision of construction of isolated power plants, and all of the engineering work, excepting structural, embracing heating, ventilation, electrical and plumbing work, kitchen and laundry layouts, refrigeration systems, pipe lines and distribution systems between buildings, sewage and sewage disposal systems, fire protection and work of similar nature incidental to institutional and building work. Location, Baltimore.

113 Lubrication engineer on sale of high-grade lubricating oils, must have considerable experience in connection with the operation of steam engines and mill machinery; one who has made a specialty of studying lubrication; a diplomat and a good mixer. Would be expected to visit large plants, inspect engines and machinery in connection with the recommendation of proper lubricants to be used, which necessitates a full knowledge of this phase of the business. Salary depends upon ability of the man.

201 Librarian for engineering library devoted to mechanical, electrical and mining engineering. Preference would be for one who has had some engineering training, preferably collegiate, who is able to translate and abstract articles published in technical German and French, especially in the former, and who can keep the library up to date, help students in finding references, assist members of the faculty in compilations, etc. Salary for present not over $1000 a year. Location, New York State.

202 Technical graduate for concern manufacturing small accurate electrical apparatus and motors. Work will consist of investigations on accuracy and limits of accuracy in matters of production, working out specific basis for determining production in regard to quantity and quality. Some chemical knowledge required. Applicants are requested to give details on technical education, business experience, references, age and salary. Name confidential; apply through the Society.

203 Busy executive of large western machine works wants an assistant; must be ambitious, energetic young man, technically trained, experienced in handling office details, correspondence, salesmen and with some personal selling ability. Prefer one with knowledge of wood working machinery. This is an exceptional opportunity for one seeking a wider horizon than possible through general shop work.

205 Draftsman or designer familiar with proportions and design of Curtis turbine blading; must be capable of laying out blading to secure the best steam efficiency, including plotting and calculations. Location, Connecticut. Applicant must have the actual experience for this work, otherwise useless to apply. Name confidential; apply through the Society.

206 Man to settle disputes that may arise along railway construction work and operation. Will necessitate a great deal of traveling. Preference given man with knowledge of car building, able to act or qualify as chief car inspector. Apply through the Society.

207 An engineer, thoroughly experienced in the design and operation of oil engines. Should be familiar with foreign development and practice. State age, experience, compensation. Name confidential; apply through the Society.

208 Vice president and general manager of sales; an engineer of highest mechanical experience and ability; able to direct advertising department and look after domestic and foreign sales of large shop employing 1500 men. Name confidential; apply through Society.

209 Wanted: Tool designer with several years' experience on jigs and fixtures, for the production of small interchangeable parts for electrical apparatus, also typewriter and adding machines. Only those with practical shop experience need apply. Applicants please state age, references and salary.

210 Mechanical engineer to take charge of power plant connected with brick manufacturing concern having four factories near Trenton, N. J.

211 Wanted: Assistant to superintendent of machine shop in Milwaukee. Man with technical education and one capable of taking charge of perfecting new apparatus. State experience and salary desired.

210 Wanted for the next college year, an instructor in machine shop practice in a large western university. Salary $1600. Applicant must be a skilled machinist, capable of designing and making special tools used in manufacturing machinery. Familiarity with scientific methods of shop management is desirable.

212 Mechanical engineer to take charge of power plant connected with brick manufacturing concern having four factories near Trenton, N. J.

213 A young man with technical training, who has had two or three years' experience in the construction or operation of gas plant or gas plant machinery, wanted by a manufacturing firm in Middle West for installation work in this country on a new high-grade apparatus used in the gas industry. Good opportunity for the right man. Name confidential; apply through the Society.

214 New Jersey concern are in constant need of men about four years out of college, willing to start at $25 a week as apprentices. Character the first requisite, after that general ability for executive and manufacturing work. Apply through the Society.

215 Assistant to president; bright, energetic young engineer, not over 30, with shop and drawing room experience and a basis of good common sense and personality. Excellent training for young man who has the personality and ability to advance and learn the lessons from daily experiences, who can adapt himself to the special conditions and become conversant with line of manufacture of pneumatic machinery, saws and saw-mill machinery, manganese steel castings. Location, St. Louis, Mo.

216 Assistant to works manager of concern manufacturing pneumatic machinery, saws and saw-mill machinery, manganese steel castings. Requirements and conditions same as stated in No. 215. Location, St. Louis, Mo.

217 Competent and trained engineer who is specialist in safety appliances wanted by state industrial commission of the Middle West.

218 Master mechanic for Brooklyn mill; man who understands steam engineering and general repair work on machines, with shop experience; will probably pay $2000 to $2500, according to ability.

219 Mechanical engineer to take the position of chief engineer in a rubber company's factory. Experience in construction work, executive ability. Applicant should be not less than 30 and not more than 45 years of age. Only men having practical experience need apply. Works include machine, electrical and carpenter shops, drafting room and office force. State salary expected, experience and age. Location, New York.

220 Technically educated man for catalogue work on can-making machinery. Applicant need not be educated in can-making nor can-making machinery, but must have the qualifications for describing clearly the essential features of machines and details of operation.

221 The sales department of a large manufacturing company in New England is looking for a good, live, young man, who is well educated, has a knowledge of mechanics, and is a good correspondent. A graduate mechanical engineer with some commercial experience would be preferred. A full reply giving age, whether married or single, experience, present occupation, references and salary expected will receive attention and will be treated confidentially. Name confidential; apply through the Society.

MEN AVAILABLE

100 Engineer, young, married, technical graduate with thoroughly practical experience in management of mechanical workshops, at present employed as manager of a plant producing a well-known line of motor trucks, would like to make a similar connection with another company in any line of manufacture. Location immaterial.

101 Junior member, technical graduate, six years' experience power plant efficiency, operation, design and construction work. Wants position as mechanical or efficiency engineer. Salary $175 to $200 per month.

102 Mechanical engineer, thoroughly experienced in design of precision machine tools, heavy hydraulic hoisting and pumping machinery; can handle men and get results; familiar with modern methods, and operation of alternating and direct-current apparatus.

103 Member, graduate mechanical engineer, desires permanent connection as designing or production engineer with concern manufacturing gas, gasolene engines or automobiles. Eight years' experience in these lines. Age 30; married. Can give best of references.

104 Member, graduate of Massachusetts Institute of Technology; 15 years' experience in textile manufacturing, mill engineering and shop management; broad executive experience as works manager and superintendent of large machine shop. Experienced in most advanced practice in shop organization. Position desired as factory manager or superintendent of plant engaged in staple manufacturing.

105 Member, now employed, desires change, capable mechanical engineer or chief draftsman, to take complete charge of drafting room designing boilers, engines, locomotives, steel cars, special mechinery, power plants and structural work. Location immaterial.

106 Graduate electrical engineer, nine years' experience with present employer, a well-known pioneer motor truck manufacturer, holding positions as designing and production engineer, factory manager, and branch manager in charge of sales through western New York and Pennsylvania. Able executive.

107 Executive mechanical engineer of wide experience, capable of filling position of chief engineer on large projects, is open for engagement. Familiar with heavy construction work and the economical methods of handling materials. Can organize a large construction force that will produce results. Will undertake any engineering work on salary or commission. Member, married, age 40.

108 Heating, ventilating and power plant, member, 28 years' experience, available for superintendence and design with architects or consulting engineers.

109 Mechanical engineer or superintendent for large corporation; experience along broad mechanical and steam power lines; executive, with ability to handle large number of men, or will consider proposition to act as consulting engineer.

110 Member, desires position as works manager, superintendent, or chief inspector. Good executive, has handled men for the last 12 years. Experience covers a period of 22 years. Both large and small machinery, including printing presses, conveying machinery, typewriters, and ball, roller, and thrust bearings. Experience in organizing and directing inspection departments. At present employed. Permanent position desired.

111 High-grade electrical and mechanical engineer, 38 years of age, first-class executive, who has headed large organizations, both in constructional and manufacturing work. Has had charge of important government work as well as corporation work. Experienced in sales organization, decidedly aggressive and a good developer. Desires position with manufacturing or construction company. Apply through the Society.

112 Member; electrical and mechanical engineer, has had wide experience, building, managing, and operating electrical and cement plants; last five years in active management of cement plant in Middle West; can give best of references East and West. Will go anywhere.

113 Junior member, age 31, single, graduate in mechanical and electrical engineering departments of large technical school, desires to make connection with firm where industry, capacity, and conscientiousness will be appreciated and rewarded. Applicant has ten years' experience in operating, designing and constructing substations, designing steel towers, selling small gas engines, city railway work. Can give best of references, and will start at a reasonable salary.

114 Teacher of mechanical engineering subjects in an eastern university desires a change of location. Ten years experience. College work preferred. Salary $2000 to start.

115 Member, sales agent with established office in New York City, thoroughly acquainted with mechanical and electrical equipments for manufacturing plants, broad acquaintance among architects, engineers and plant-managers, desires to correspond with manufacturers of standing to act as their representative in New York and Eastern territory.

116 Junior member, 27, desires position as scale inspector or designer. Has had extensive experience with railroad track, wagon, and platform scales both as designer and sealer. Had responsible charge of scales in large plants; at present engaged in design and construction of scales. Location immaterial.

117 Member, technical graduate, 31 years of age, desires position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing, purchas-

ing, superintending construction and operating departments; consulting engineering work on large properties; power production investigations; cost reduction, experienced in mill and reinforced concrete construction work; at present employed and desires a change for advancement.

118 Mechanical engineer with complete experience from shop apprentice to agency manager wants position as assistant manager, assistant superintendent or production man; faultless record; now employed. Thorough experience in design of well-known, successful and high-grade suction gas producers and engines, Corliss engines and complete power plants; also transmission and special machinery and sales of same. On production work might consider small drawing account with bonus based on reduction made in costs.

119 Mechanical engineer, technical graduate, age 27, married; four years' experience in power plant, efficiency and construction work, desires a position with reliable concern in the East with chance for advancement. At present employed.

120 Works manager or engineer, member, graduate M.E., experienced mechanic, with broad experience here as well as abroad in the design and manufacture of automobiles and motors. Executive ability coupled with efficiency and thoroughness. At present is an engineer with automobile factory. Desires position which offers an opportunity for wider field and greater activity.

121 Junior member, at present employed, desires to change position in order to better opportunity. Two years' experience in large steel works engineering department. Two years mechanical engineer and assistant superintendent of electric company in charge of construction work, building power plants; entire charge of engineering and construction departments. Machinist, thoroughly familiar with all kinds of machinery. Experimental engineer and thorough business training. Competent in estimating, designing and erection. Desires position as superintendent or chief engineer with responsibility and chance for advancement. Would consider position with engineering concern or with consulting engineer.

122 Member; mechanical engineering graduate; age 33; wishes a responsible position as teacher, preferably of laboratory subjects. At present holds such a position, but desires one of greater opportunities. Experience: Four years in shops and drafting rooms, eight years teaching a wide range of mechanical engineering subjects, also experience in research work and as consulting engineer. Can give best of references.

123 Industrial engineer, Junior member, college and technical graduate, five years' experience, desires position with concern contemplating installation of modern and systematic methods of manufacturing or starting the manufacture of a new product; can handle men and get results. At present and for the past three years employed as an industrial engineer by a large eastern manufacturing corporation; work nearing completion, therefore desires to establish new and permanent connection with manufacturers desiring executive of energy and ability.

124 Member, technical graduate, 1907; 29 years old; married; at present employed as superintendent and master mechanic. Experienced in cement business, iron and brass foundry practice, pattern making and machine shop practice, forge and smelting shop work; also experienced in boiler practice and steam engineering. Salary no object provided there is chance for advancement. Particulars of past experience on request as well as references if desired.

125 Position as superintendent or operating executive with electric railway or lighting and power company or bankers controlling such properties. Broad gaged, diplomatic, with good address and attractive personality combined with wide experience and proven ability in developing new business, eliminating troubles and reducing power costs. Six years of shop and road experience with large manufacturer of steam turbines and electrical apparatus. Five years as superintendent of power with large interurban railway and power company. Accustomed to handling customers' complaints, organizing and directing employees, specifying and purchasing equipment and materials. At present assistant to the electrical engineer of a 60,000-kw. power system.

126 Member, with exceptional technical training, both mechanical and electrical; five years' experience in research work on steam turbines, centrifugal air compressors and jet pumps; four years complete charge of designing, manufacturing, testing and installing vacuum cleaner systems, including the development of a complete line of portable and stationary vacuum cleaning machines; desires position with a good firm of consulting engineers, with prospect of ultimate interest in the firm; or would consider position with good manufacturing firm. At present employed.

127 Junior member, aged 27, technical graduate in mechanical engineering, married; four years' experience in factory maintenance, industrial and power plant development, design of special machinery; desires position with an engineering firm or industrial plant.

128 Member, desires position as works manager, superintendent or engineer; competent to organize all departments of manufacturing plant along modern lines; long experience; best references. Expert in developing new inventions.

129 Technical graduate; Junior member; age 30; desires position. Six years' experience teaching in an eastern technical school and in evening industrial school work. Experienced in drafting and general engineering. Energetic and enthusiastic. Would be valuable as director of industrial school, either existing school or to organize a proposed school. Would consider teaching or practice.

130 Technical graduate. Practical experience in foundries, machine shop, drafting rooms and as mechanical engineer for large manufacturing concern having charge of entire upkeep of factory, all electrical work, purchase of supplies, new work, etc. Designed and installed new power plant which is now running and had charge of all work in connection with large new factory building. Desires position with large manufacturing concern or consulting engineer. Advancement to be governed by results.

131 Mechanical engineering graduate of Lehigh University; four years in design, installation and office experience. For the past two years employed in responsible position with maintenance department of a large industrial concern. Has reached the limit of present opportunity. Desires a position with broader outlook. Age 25, married. Location immaterial. Best references.

132 Member, technical graduate, experienced as general or business manager, sales engineer and executive, desires position with manufacturing concern or as representative in New York City. Has many years' experience in foundry and machine shop practice. Broad acquaintance in the engineering, contracting and manufacturing field.

133 Technical graduate; four months as draftsman for tap and die company; 14 months with prominent automobile company in drafting room, shop and factory.

134 Mechanical engineer, graduate of Columbia University, 1911; several years' experience as factory inspector; desires position where there is good chance for advancement. Age 25.

135 Graduate engineer, five years' experience structural work, draftsman on special machinery, and inspector on outside construction; desires position along similar lines.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

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Univ. of California	Feb 13, 1912	Joseph N. LeConte	R. Guillon	P. H. Landon Univ. of Cal., Berkeley, Cal.
Univ. of Cincinnati	Nov 9, 1909	J. T. Faig	A. O. Hurxthal	E. A. Oster 1065 Wade St., Cincinnati, O.
Univ. of Illinois	Nov 9, 1909	W. F. M. Goss	A. H. Aagaard	H. E. Austin Univ. of Illinois, Urbana, Ill.
Univ. of Kansas	Mar 9, 1909	F. H. Sibley	L. C. Angevine	H. L. Newby 1501 Rhode Island St., Lawrence, Kan.
Univ. of Maine	Feb 8, 1910	Arthur C. Jewett	E. E. Fowler	A. B. Hayes S. A. E. House, Orono, Me.
Univ. of Minnesota	May 12, 1913	J. J. Flather	A. Buenger	J. A. Colvin 629 15th Ave., S. E., Minneapolis, Minn.
Univ. of Missouri	Dec 7, 1909	H. Wade Hibbard	R. Runge	L. L. Leach Y. M. C. A. Bldg., Columbia, Mo.
Univ. of Nebraska	Dec 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh Sta. A. Box 1164, Lincoln, Neb.
Univ. of Wisconsin	Nov 9, 1909	H. J. Thorkelson	M. A. Cook	R. E. Maurer 167 Prospect Ave., Madison, Wis.
Washington Univ.	Mar 10, 1911	E. L. Ohle	A. O. Schleiffarth	J. A. Watkins, Jr. 5803 Michigan Ave., St. Louis, Mo.
Yale Univ.	Oct 11, 1910	L. P. Breckenridge	L. F. Harder	M. C. Corbett 288 Orchard St., New Haven, Conn.

THE WARNER & SWASEY COMPANY

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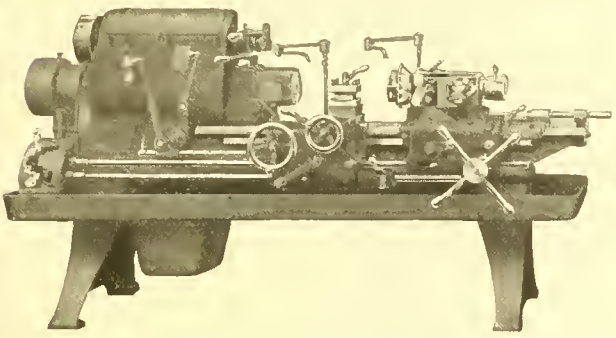
Universal Hollow-Hexagon Turret Lathes

Equally efficient for both Bar and Chucking work

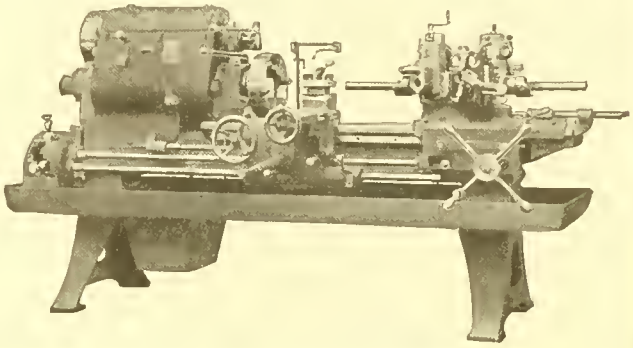
TWO highly efficient machines in ONE—combining the rapidity and accuracy of the Turret Lathe and the simplicity and adaptability of the Engine Lathe.

Two independent tool carriages—operating simultaneously; multiple cutting tools; geared-head single pulley drive; great strength, rapidity and adaptability.

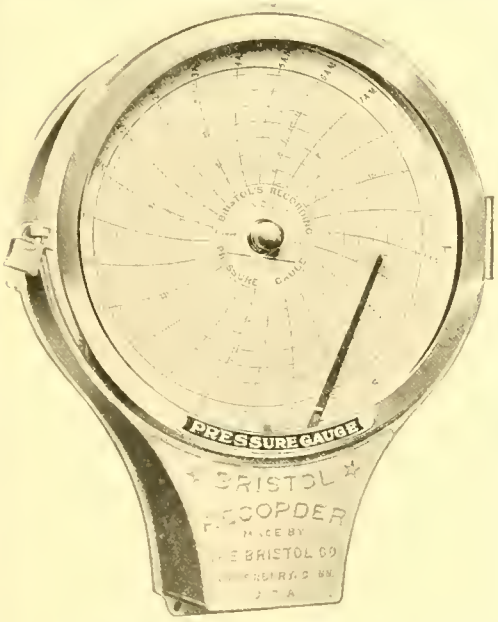
TWO SIZES—No. 2-A—Bar work 2¼"x26"; castings and forgings 12"
No. 3-A—Bar work 3¼"x36"; castings and forgings 15"



No. 2A—With "Bar Equipment"



No. 2A—With "Chucking Equipment"



The Test That Tells

Ten or fifteen years continuous service, without interruption for repairs, has often been obtained with Bristol Recording Instruments. The unique simplicity of construction of

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BRISTOL'S
REG U S. PAT. OFFICE.
RECORDING INSTRUMENTS

is responsible for their great durability and reliability in long continued service.

Take the case of Bristol Recording Gauge, Model 10, Serial No. 4038, which was shipped August 25th, 1900, and never returned for repairs until December 1st, 1913, when this recorder was found to be in fine working order except for replacement of the inking pen.

When you are in the market for recording instruments consider the fact that the practical value of automatic recorders depends chiefly upon whether the recording instrument used can be relied upon to give dependable results month after month and year after year without expert attention.

Ask anyone of your friends who has used Bristol Recorders continuously for ten years, about their characteristics, simplicity and reliability. They are unique in their simplicity of construction. More than 50,000 have been sold. Write for Bulletin C-161, mentioning your needs.

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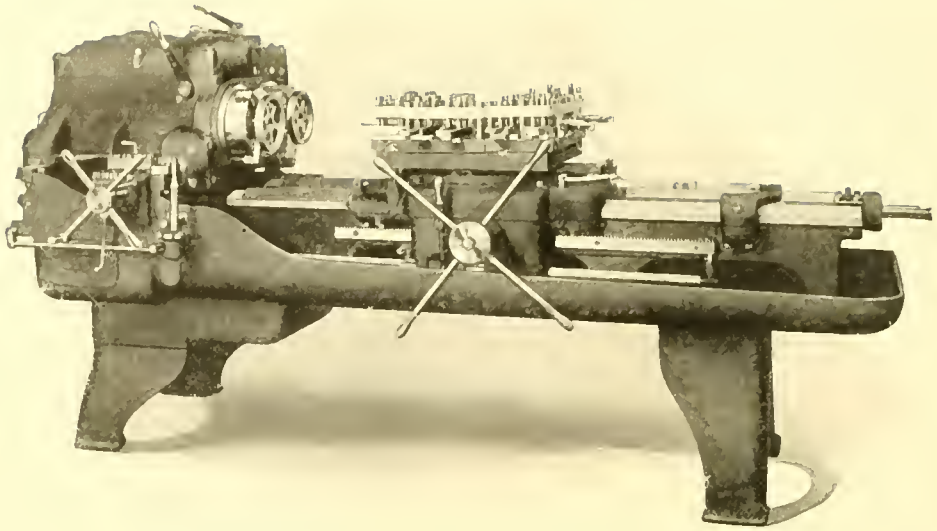
1670 Frick Bldg. Annex PITTSBURGH, PA.
753 Monadnock Block CHICAGO, ILL.



Why Not Two Instead of One?

If you make your drive strong enough, why not drive two spindles instead of one?

If you make your turret stiff enough, why not put on two sets of tools instead of one?

If the operator has to stop the machine to put in one piece, why not have him put in two instead?

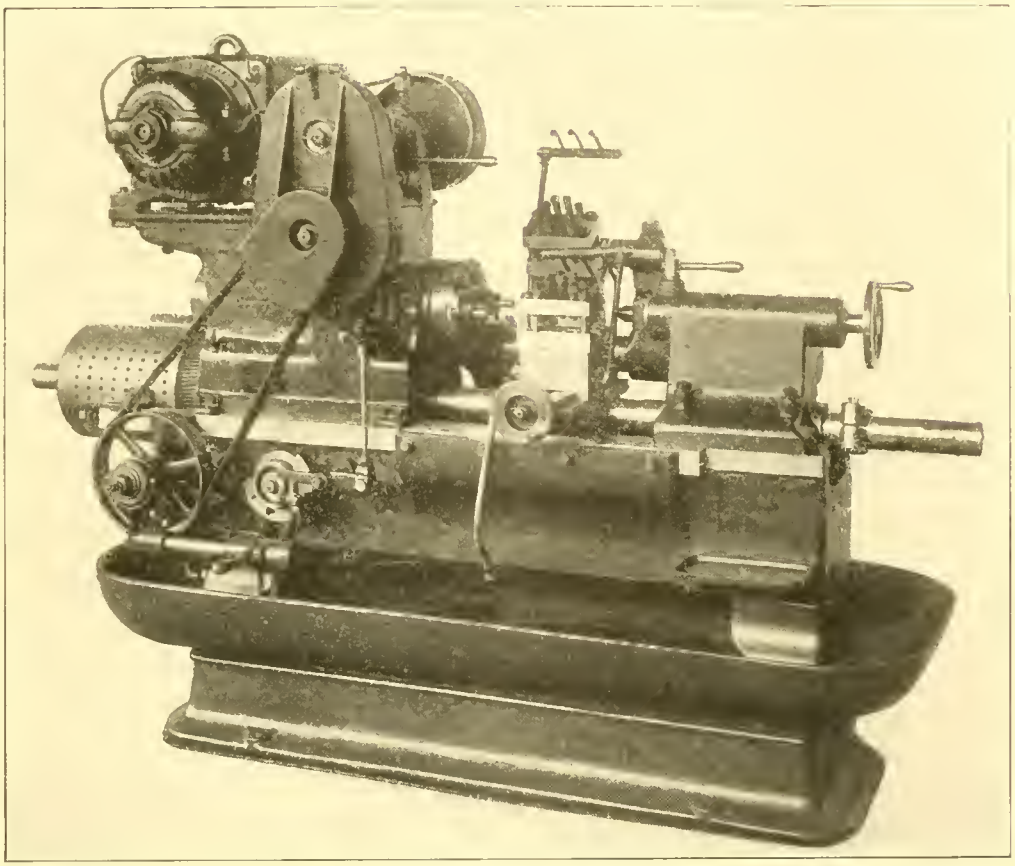
If you have any desire to practically double your output per machine, per man and per dollar of investment, why not get a Double Spindle Flat Turret Lathe for your chucking work?

JONES & LAMSON MACHINE

97 Queen Victoria Street,

Germany, Holland, Switzerland, Austria-Hungary: M. Koyemann, Charlottenstrasse 112, Düsseldorf.

This Is the Fay Automatic Lathe



Fitted with a French Motor for a French Shop

It works just as well fitted with an American Motor for an American Shop

For the automatic turning of work held between centers—particularly second-operation work, which can be finish-turned automatically on a true arbor. One man runs two machines, and they keep him busy. He stands between them and keeps them at work without stirring from his position. He fills the arbors while the machines are running. No lost time.

COMPANY - Springfield, Vt.

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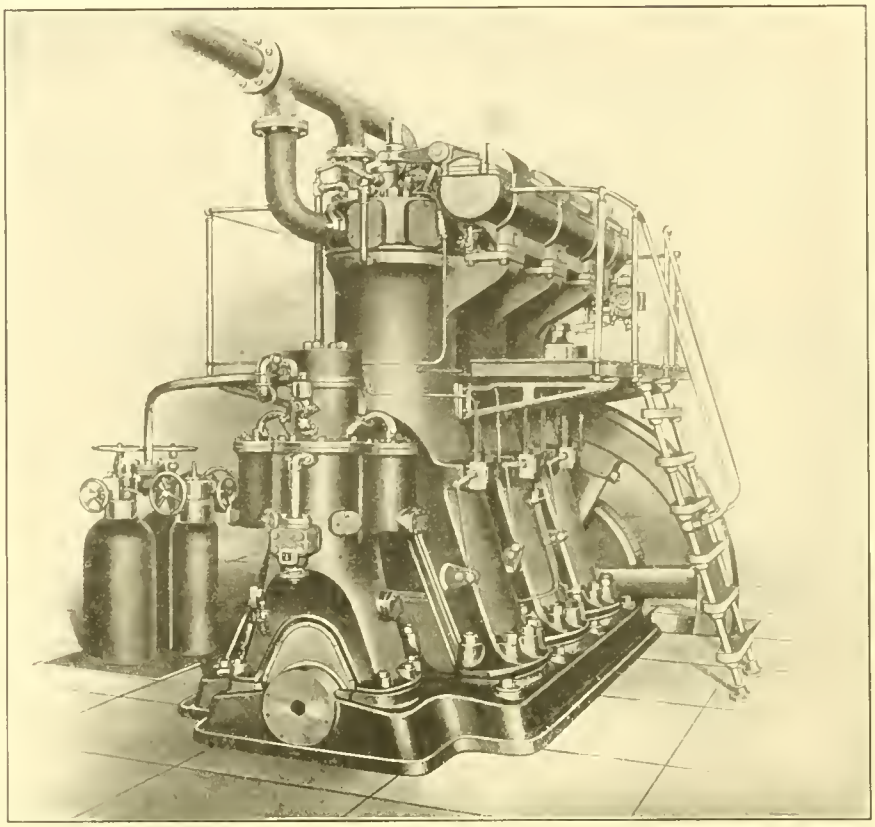
France, Spain and Belgium: F. Auberty & Co., 91 Rue de Maubeuge, Paris. Italy: W. Vogel, Milan.

Fulton-Tosi Oil Engines

(DIESEL TYPE)



Economy-Reliability-Simplicity

Designed in accordance with the most approved modern principles.

Operates on lowest grades of liquid fuels without requiring any desulphurizing or refining process.

Fuel consumption less than 6 gallons per 100 BHP hours.

Direct connected injection air compressor forming an integral part of the engine.

Centralized control enabling operator to start engine from one point.

BULLETIN 800 GIVES DETAILS

FULTON IRON WORKS

ST. LOUIS, U. S. A.

New York Office: 82 Wall Street

Established 1852 Incorporated 1871 New Plant Erected, 1912

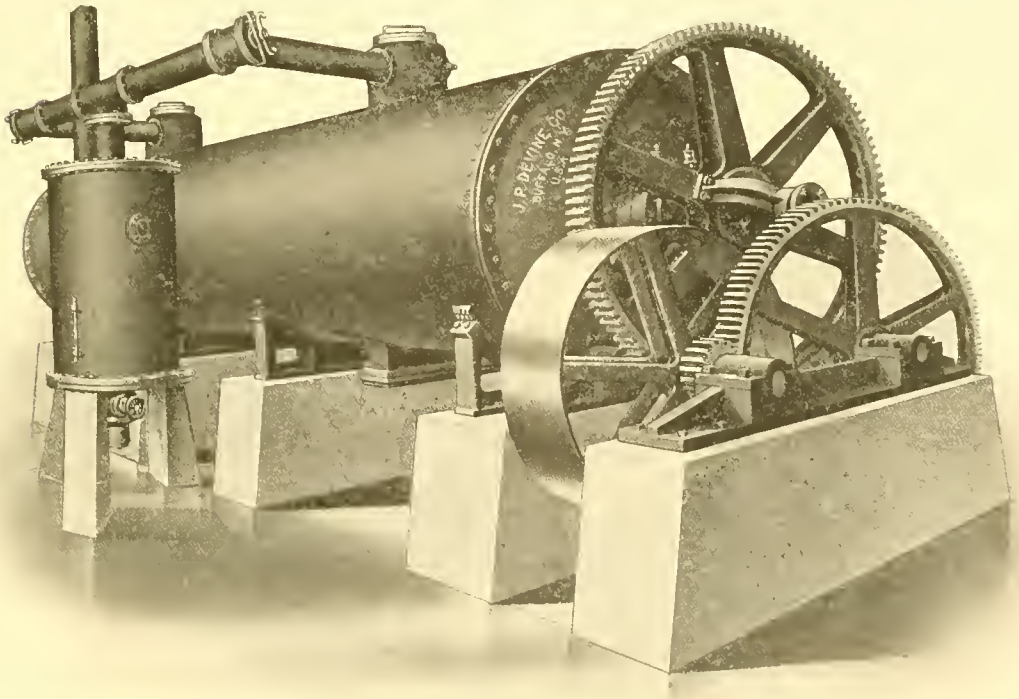
"SIXTY YEARS OF SUCCESSFUL MANUFACTURING"

Drying Problems May Confront You

Our

Vacuum Drying Apparatus

removes moisture, at lowest temperature, rapidly, thoroughly, uniformly, economically. Thirty years of experience in this one field of activity cannot help but be of value to you.

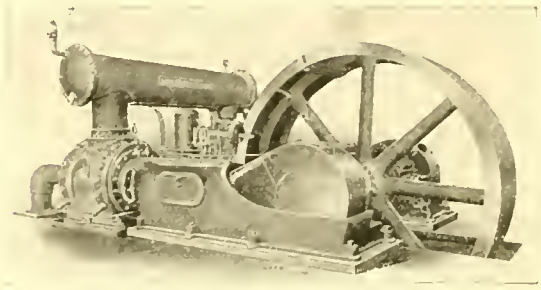


The thousands of installations in daily operation and the many repeat orders are the best evidence of our claims to be of service.

J. P. DEVINE CO.

1372 Clinton Street **Buffalo, N. Y.**

ANALYZE THE SPECIFICATIONS



Class "PB" Power Driven Compressor—Bulletin No. 3107

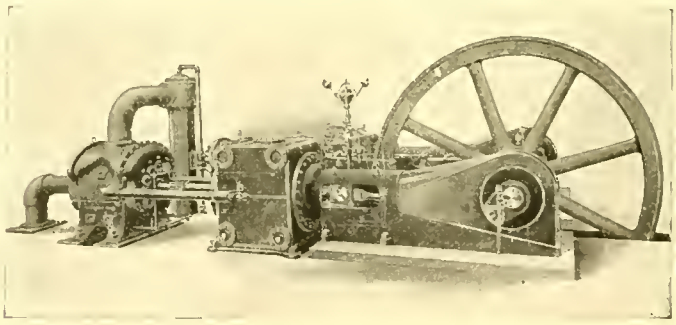
In compressor manufacturing, as in other lines, there are so many opportunities for the substitution of inferior materials and workmanship, so many ways of imitating a high grade construction and design, at a much lower cost, that it behooves the user to demand specifications of sufficient minuteness, *TO ENABLE HIM TO KNOW WHAT HE IS BUYING.*

Ingersoll-Rand specifications are nothing more nor less than an actual description of what the company offers the purchaser for the money they ask him to invest.

You have a feeling, not alone of thorough acquaintanceship with the superiority of Ingersoll-Rand compressors, but one of perfect reliance and the assurance of receiving full value for your investment.

Insist upon knowing what you are buying—*ASK FOR SPECIFICATIONS.*

BULLETIN 3101 COVERS THE LINE



Class "CH" Corliss Steam Driven Compressor

INGERSOLL-RAND COMPANY

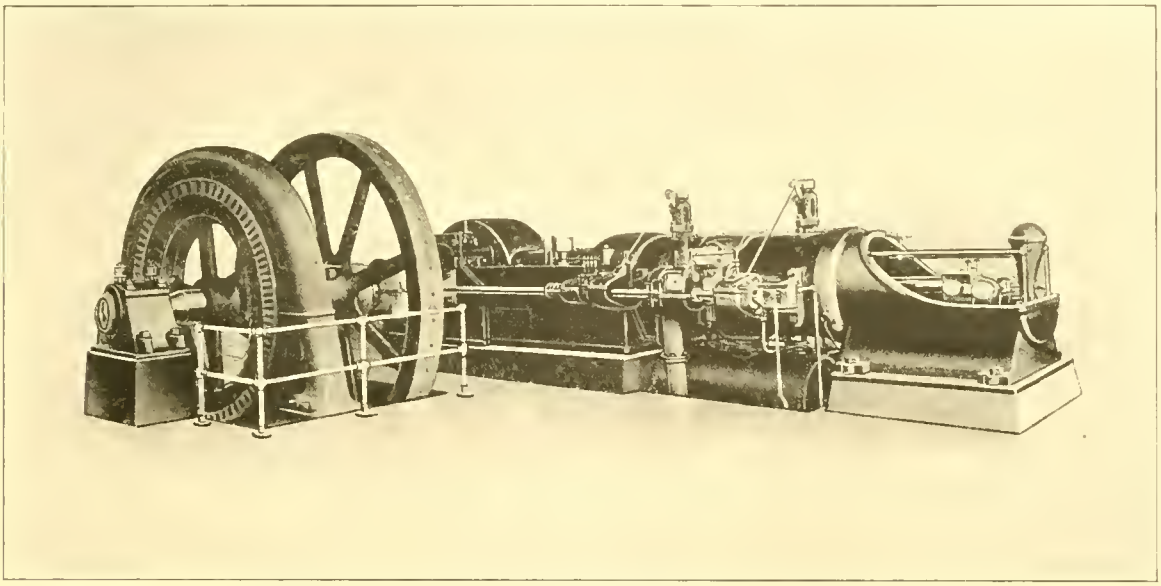
NEW YORK — Offices the World Over — LONDON

AIR HOISTS — PNEUMATIC TOOLS

10-C

Oil-Burning BECO

THE newest, simplest and most economical prime mover in the world. A two-cycle double acting, horizontal, oil burning engine, operating on the Diesel principle and designed and constructed on the lines of a steam engine.



"The Engine Without a Rival"

For

Simplicity, Efficiency and Durability

STANDARD SIZES 300 TO 600 B. H. P.

THE BECO engine utilizes fully 38% of the fuel expended and works with the cheapest grades of oil fuel. There are, all told, but two fuel injecting valves and two starting valves, one of each for each cylinder end. The air pumps underneath the engine cylinder are driven from the tail rod crosshead by means of a rocker arm.

The elimination of excessive repairs has been a special object of our design. Our shaft is made of a straight piece of forged steel with crank discs shrunk on end. The weight of the piston is carried by crossheads on each end of the piston rod. All working parts are exposed and easily accessible.

WE GUARANTEE

our engines as to any defects due to faulty design, material and workmanship.

The regulation to be sufficiently close to operate A. C. generators in parallel.

100 B.H.P. hours with a fuel consumption not in excess of 7½ gallons of crude or refuse oil when operating at or near full load, and 8½ gallons when operating at or near one-half load.

Our fuel guarantee commences when the purchaser accepts the engine and continues for one year during the actual operation of the engine.

Bulletin of details on request

HERBERT B. RUST, Sales Agent
14-22 Peck Street, Providence, R. I.

THE BROWN ENGINE CO. Fitchburg, Mass.

VARYING PRODUCT

UNIFORM PRODUCT

Uniform Power Helps Assure Uniform Product

As a box-jig assures uniform drilling and cheap production while hand laying off is both inaccurate and costly so individual G-E electric motor drive on each of your machines assures exact duplication of power conditions by the turn of a handle.

With a G-E motor on each of your machines either perfectly sustained speed under constant conditions is available or else any definite speed variation required is immediately obtainable by the turn of a handle placed convenient to operator. A pointer on an index dial shows what the result will be and no guess work is required. The starting or stopping of other machines does not break or chatter-mark the work but each machine is independent of all others.

No slipping belts or engine "dead centers" combine with lineshaft torsion to produce speed variations as is the case with long engine driven line shafts. Every power condition can be duplicated at will to assure uniform product.

The General Electric Company has had more experience than any other Company in designing complete electric power equipments for every industry. From the mass of data at its disposal and the unequalled number of standard motors, controllers, etc., your power requirements can be promptly met whether you desire to use power from the local electric power company or from your own power plant.

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Largest Electrical Manufacturer in the World
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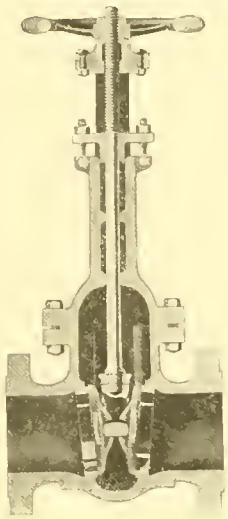
Why NELSON STEEL VALVES Are A Safe Valve Investment



The use of high pressure superheated steam calls for a valve that will stand *excessive* strains, a valve made of close grained, thoroughly annealed steel—ductile, yet of great tensile strength. The steel used in Nelson Valves meets the most severe conditions of high pressure and superheat. Each Nelson Valve is tested to more than twice its working pressure. The slightest leaking or "sweating" is sufficient cause for its rejection. Selected material, careful workmanship, rigid censorship, thorough testing, are your safeguards in using Nelson Valves—the large list of satisfied users is your assurance that you are getting full valve-value.

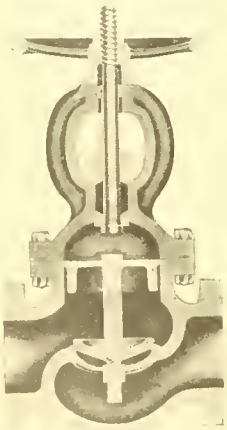
Double Disc Steel Gate Valve

Nelson Steel Gate Valves have but three simple working parts, two steel rocking discs, faced with forged, monel, disc rings; and one steel wedge, pinned solid with monel stem. These three parts form a flexible unit that adjusts itself perfectly to every condition—that makes an absolutely tight valve, even when valve seats are distorted by unequal expansion due to superheat conditions. Nelson Double Disc Steel Gate Valves perform the three functions of the ideal gate valve:

1st: When closed, they hold the steam pressure.

2nd: When partly open, they do not chatter, because the discs are supported by machined guides on the valve body.

3rd: When open wide, they leave a passage that is free and clear — no more friction through the valve than through the pipe itself.



Nelson Steel Non-Return Valve

A valve for working pressures up to 400 lbs. and temperatures up to 800 degrees Fahrenheit, with steel body, bonnet, yoke and gland, and monel stem and seat, and one-piece monel metal disc and piston. Operates automatically, like an ordinary check valve, but can be used as a stop valve by screwing down hand wheel.

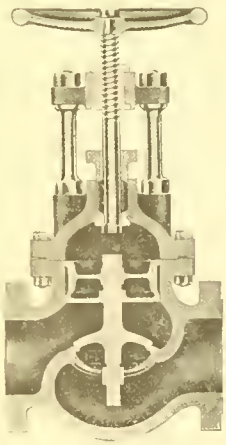
Contains internal dashpot clamped between the bonnet flanges, which is always at the same temperature as the other working parts, giving free travel to the piston. The dashpot may be renewed if desired. Since the piston is made the same depth as the dashpot no shoulder is formed in operation, and "sticking," so fatal to a valve of this type, is done away with.

The fact that the piston and disc are cast in one piece prevents internal troubles, as they cannot chatter loose, but must act as a single unit.

A lip located below the valve disc absorbs the wear caused by wire-drawing, and leaves the seat always in good condition.

Heavy Duty Steel Throttle Valve

The Heavy, "Navy" Steel Globe or Angle Throttle Valve has a steel body with bronze or monel metal stem, disc and seat Seats are removable and regrinding, and the swing-bolted stuffing box allows of repacking when the valve is open and under pressure. The use of curves instead of straight lines in the casting of Nelson Steel Valves produces solid castings free from flaws or weaknesses, and makes for unusual body strength. Extra Heavy Duty "Navy" Steel Throttle Valves, for temperatures up to 800 degrees Fahrenheit, and working pressures up to 400 lbs. are each tested to 1000 lbs. Throttle valves are also built with an internal by-pass, automatically opened and closed by means of the valve stem. We recommend internal by-pass valves on sizes above six inches.

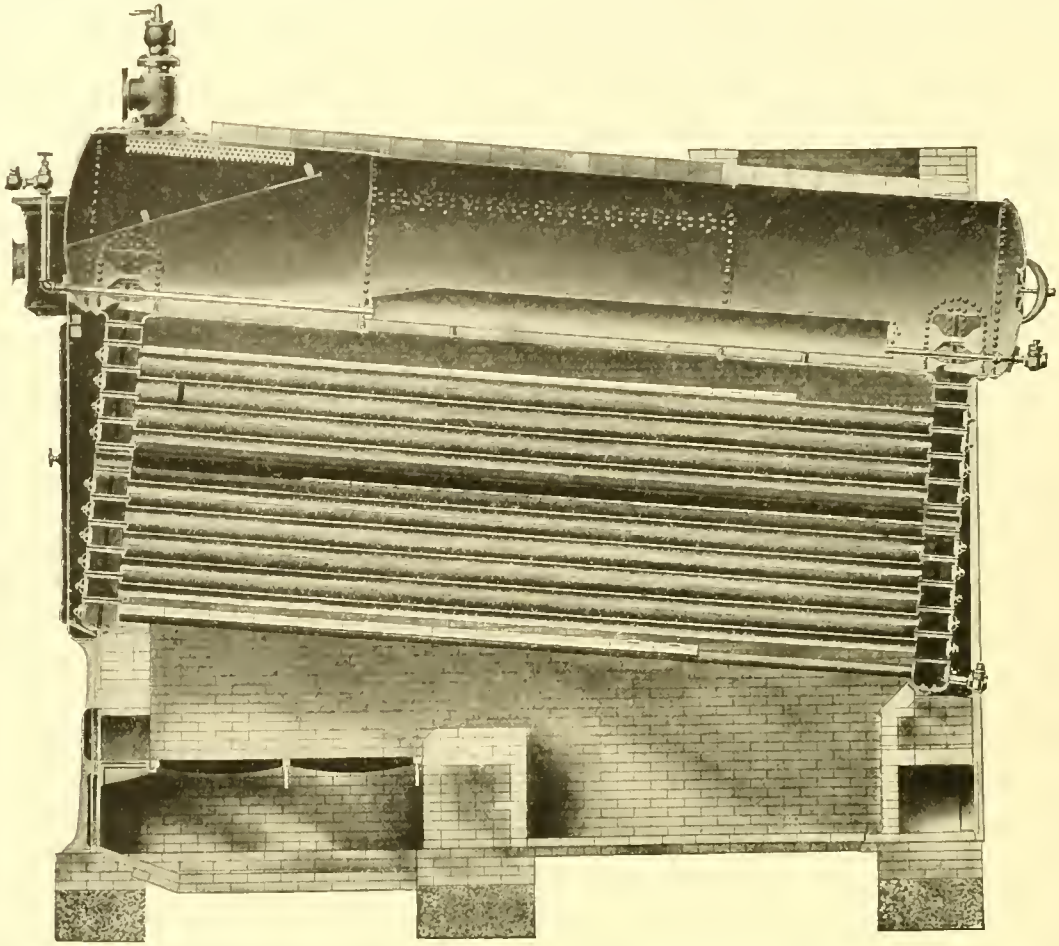


Nelson Steel Valves are but one member of a large family of valves, designed for almost any size, place or purpose—all made to conform to the Nelson standard of utility and efficiency. We're always ready and willing to "talk valves" to anyone interested enough to write us about them.

Nelson Valve Company

CHESTNUT HILL PHILADELPHIA

HEINE BOILERS



High Power—High Efficiency

THE Heine Boiler meets these important requirements of modern boiler practice.

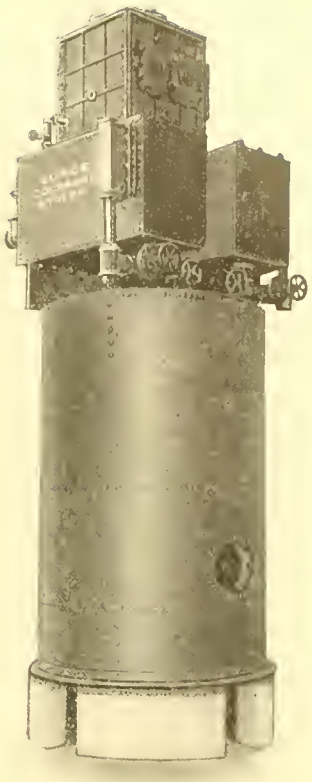
First as regards high power—Owing to the construction of the Heine water leg, the area for the flow of water and steam is many times that in ordinary water tube boilers, so that there is **free circulation** and therefore **boilers may be forced to large capacity.**

Second, as to high efficiency—These boilers have two horizontal passes and a **long path for the travel of the gases,** thus giving **high efficiency of heat absorption.** Baffle tiles over the lower row of tubes improve furnace efficiency, so that the combined furnace and boiler efficiency is well up toward 80%.

For further information, write for our booklets "Boiler Logic," "Space Occupied by Water Tube Boilers" and "Superheating."

HEINE SAFETY BOILER CO.

2465 Marcus Ave. (65) **St. Louis, Mo.**



WHY THE SORGE-COCHRANE HOT PROCESS SYSTEMS FOR SOFTENING WATER FOR BOILERS GIVES TOP-NOTCH RESULTS

First: Because the water is treated hot. Chemical reactions *are more rapid in hot water than in cold water.*

Second: Because the resulting precipitates are *larger* and *heavier* and *settle more rapidly*, hence more perfect separation with a given capacity of settling tank.

Third: Because the substances resulting from the transformation of the scale-forming ingredients are *less soluble* than in cold water, hence *less* remain in solution in water treated hot than in water treated cold.

The accuracy of the above statements will be confirmed by anyone who has had occasion to pass water from an ordinary cold process softening system through a feed water heater. Although the water may be clear when it leaves the softening system, there is invariably a heavy deposit of scale and sludge in the heater.

In the Sorge-Cochrane Hot Process System, the water is heated before it is treated chemically. This has the advantage not only of making the treatment more rapid and perfect, but also of driving off air and gases held in solution in the water, thereby rendering it non-corrosive, recent researches having demonstrated conclusively that corrosion by boiler feed water is conditional upon the presence of dissolved air.

The Sorge-Cochrane Hot Process Water Softening System, besides being the most perfect water softener, is also a perfect water heater, giving all the benefits and possibilities of the best open feed water heater, and can be used with engines exhausting free to atmosphere or against back pressure. It can also be combined with the Cochrane Meter to indicate and record the rate at which the water is pumped into the boilers, giving an accurate gage of the boiler plant economy.

Cochrane Softening Systems are not supplied in one unchanging form for all conditions, but are modified to adapt them economically to the requirements of the individual plant. We have different processes and apparatus for:

Waters containing temporary hardness only;

Waters containing large amounts of sulphates or permanent hardness;

For use where only part of the water requires softening;

Where the water contains large quantities of magnesia;

Where the water is wanted cold, although we recommend heating the water as much as possible, and with some waters a preliminary heating to 140 or 150 deg. F. is positively necessary in order to get wholly satisfactory results.

We also have a softening system which can be installed at small expense where Cochrane or other open feed water heaters are already in service.

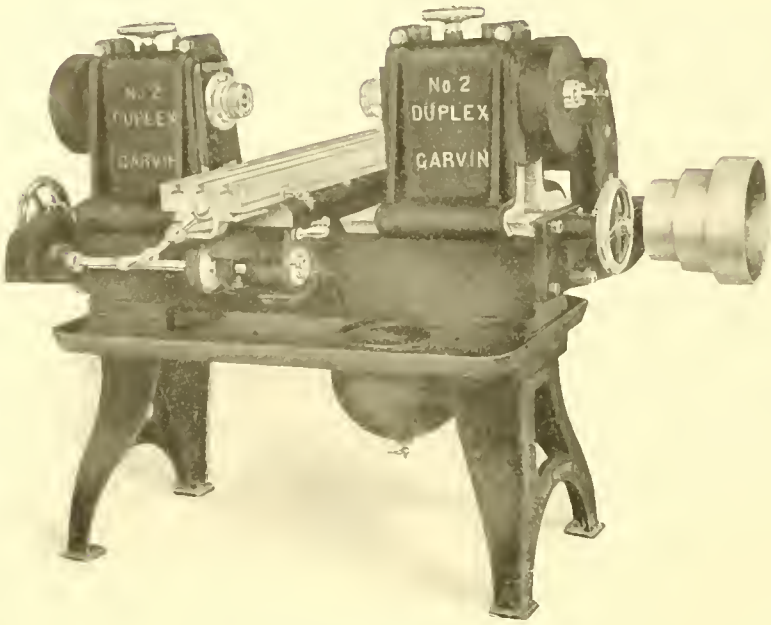
Send us an analysis of the water that you are using, or wish to use, for boiler feeding, or ship us a gallon sample prepaid, and we will give you our recommendations as to the best method of handling your water-softening and heating problems.

Would you like a copy of our new book on "*Steam Plant Economies Due to the Use of Hot Soft Water in the Boilers*"?

HARRISON SAFETY BOILER WORKS

3199 North 17th St. Philadelphia, Pa.

THE GARVIN MACHINE COMPANY



GARVIN No. 2 Duplex Milling Machine

Table Feed. . . . 30 in. Center to Table. . . . . .3 to 9 in.
Between Spindles. . . . .4 to 16 in. Use Code. . . Antepast.

Manufacturers of
MILLING MACHINES
Numerous Styles and Sizes
SCREW MACHINES
MONITOR LATHES
FORMING MACHINES
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TAPPING MACHINES
SLOTTING MACHINES
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CUTTER GRINDERS
DUPLEX HORIZONTAL DRILLS
HAND LATHES
SPRING COILERS
and
SPECIAL MACHINERY

OFFICE AND WORKS
137 VARICK ST.
NEW YORK CITY

Visitors Welcome

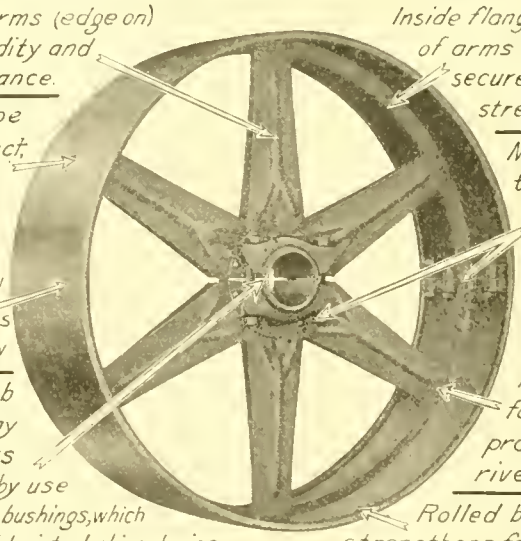
SOME SUPERIORITIES *of*
"AMERICAN" STEEL SPLIT PULLEYS

Flat "A" braced arms (edge on) give perfect rigidity and least air resistance.

Grooved air escape improves belt contact, yet the face is not weakened

Rim: One thickness of steel. Snugly doweled at the joints. Combines lightness with durability

Tight clamping hub eliminates key-way and set screw. Fits different shafts by use of interchangeable bushings, which are immovably fixed by interlocking device.



Inside flange, to which ends of arms are riveted, secures extraordinary strength and trueness

No need to strip the shaft. Fit two halves of pulley together, then tighten clamping bolts evenly.

Arm rivets do not go through face, with possible protrusion of rivets.

Rolled bead on rim, strengthens face at edge.

"American" Pulleys are made in diameters 3 to 60 inches inclusive and are guaranteed to do double belt duty under any conditions not requiring a special pulley. DEALERS EVERYWHERE

THE AMERICAN PULLEY COMPANY

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Steel Mine Ties
Car Hauls
Car Retarders
Self Oiling Wheels

FAIRMONT
COAL MINE EQUIPMENT

Power Coal Augers
Box Car Loaders
Portable Mine Pumps
Mine Fans

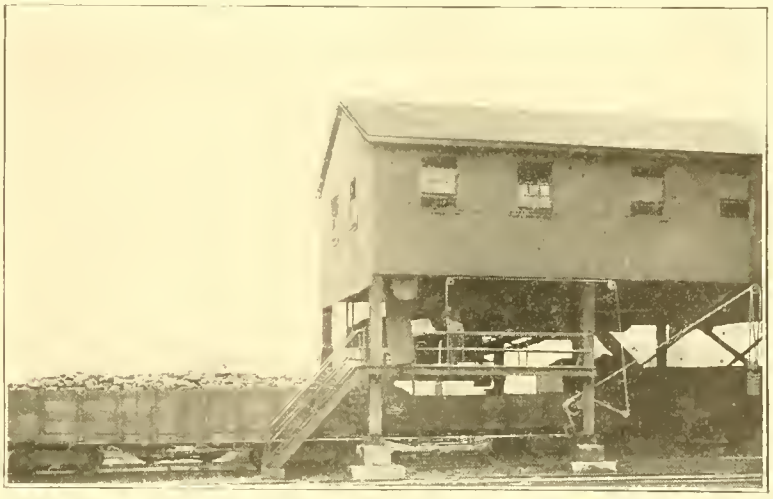
Eliminates Spilling and Saves Labor

Irrespective of weather, slippery tracks or bad brakes, the

FAIRMONT Railroad Car Retarder

gives the dumper on the tipple complete control of the cars to be loaded.
Easy to install and operate. Effects saving in labor, often enabling owners to dispense with the services of one man.
Feeds the cars regularly and prevents spilling of coal over tracks. Soon pays for itself.

Write for Bulletin No. 10.



6 Retarders on this tipple of Four States Coal & Coke Co.

Fairmont Mining Machinery Co., Fairmont, W. Va.

Automatic Inclined Elevator Delivering Bottle Cases to Conveyer Line

COST-CUTTING, LABOR-SAVING

Conveying Machinery

—Both Gravity and Power—

GRAVITY ROLLER CONVEYERS
GRAVITY WHEEL CONVEYERS
AUTOMATIC ELEVATORS
GRAVITY ROLLER SPIRALS
GRAVITY SPIRAL CHUTES, Etc.

For handling merchandise in boxes or packages having one flat surface; brick, building supplies, lumber, lath, shingles, flooring, cooperage stock, pig iron, etc.
Branch offices in every leading American city, with engineer in charge. Conveying systems designed for all industries, including blue print and proposal free of cost in case of non-acceptance.

Gravity Roller Conveyer Delivering Boxes into Freight Car

ATTENTION OF MECHANICAL ENGINEERS

Cut out this coupon, attach it to your letter head and we will mail our full set of catalogs and bulletins illustrating and describing the Mathews line of Standard equipment, consisting of Gravity Conveyers, Automatic Elevators, Gravity Roller Spirals, Gravity Spiral Chutes, etc. Sooner or later you will have use for the information given in our literature.

We Designed the First Steel Ball-Bearing Gravity Roller Conveyer Put on the Market. Our Patents Cover the Most Successful Mechanical Devices Employed in Modern Conveying Equipment. Specify "Mathews" and Play Safe.

SPEED · THE MATHEWS WAY · MATHEWS GRAVITY CARRIER COMPANY · THE SAVING WAY · ECONOMY

Main Office and Factory
Ellwood City, Pa.

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TORONTO, ONT.
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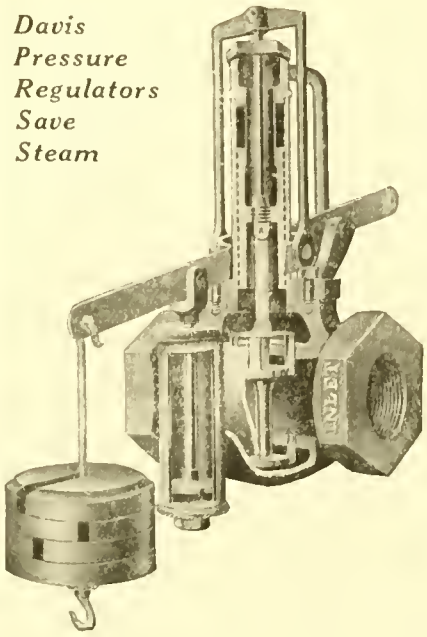
Davis Pressure Regulators Save Steam



Made in all sizes from ½ to 14 inch with either screwed or flanged ends.

Put this valve on your steam line and forget about the pressure

Besides the economy of the thing, there is much satisfaction in being able to get any pressure you want in your plant regardless of the boiler pressure.

No matter what the operating conditions may be, if the result you want to get is a lower pressure for a given purpose, you have at your command the

DAVIS Pressure Regulator

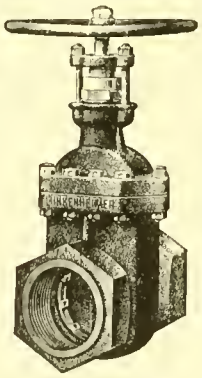
This automatic valve may be set for any delivery. Fluctuations in the high pressure do not affect its action, and it is good for years of service because it is very simple in construction.

All Davis Pressure Regulators are sold on approval at our risk. They must satisfy you fully or there is no sale. Let us have your inquiries.

G. M. Davis Regulator Company

439 Milwaukee Ave., Chicago

New York *Boston* *Philadelphia* *Pittsburgh*
St. Louis *San Francisco*



IRON BODY BRASS MOUNTED

LUNKENHEIMER "VICTOR" GATE VALVES

Made in **Standard, Medium, Heavy** and **Extra Heavy Iron Body Brass Mounted** Patterns, **"Puddled" Semi-steel** and **Cast Steel,** with either **Stationary Stem** or **Outside Screw** and **Yoke,** and **with** or **without By-pass.**

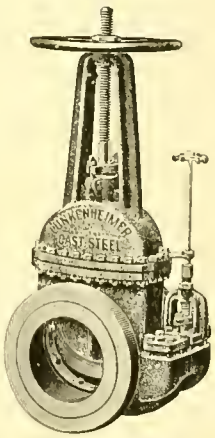
The valves are double-seated, can be packed under pressure and **all parts subjected to wear are renewable.**

Lunkenheimer "Victor" Gate Valves are also made entirely of iron for use in handling cyanides and other acids which attack brass.

Specify and insist upon securing genuine **Lunkenheimer make.** Do not accept substitutes—they are never as good as the genuine.

Your local dealer can furnish them; if not, write us.

Write for Catalogue



CAST STEEL

THE LUNKENHEIMER CO.

"QUALITY"

LARGEST MANUFACTURERS OF HIGH GRADE ENGINEERING SPECIALTIES IN THE WORLD

Executive Offices and Factories: CINCINNATI, OHIO, U. S. A.

New York, 64-68 Fulton St. | Chicago, 188 N. Dearborn St. | Boston, 138 High St. | London, S. E., 35 Great Dover St.

6-4

Concerning Special Machinery

OUR forty years' experience in building special machines for knitting mills, paper making, wood working and nearly every other kind of purpose, has fitted us to help you solve your own problems.

Our energies are devoted to your interests. If you have a new idea you wish to put into form our whole plant is at your disposal. And remember all such work is held as strictly confidential.

We gladly submit preliminary estimates from blue prints. Send yours to-day

C. H. COWDREY MACHINE WORKS

FITCHBURG, MASS.

Contractors, Builders and Designers of Special Machinery

Machines We Have Made—

Hosiery Knitting Machines
Bobbin Turning and Boring Machines
Celluloid Turning Machines
Pointing Machines
Shoe Machines
Optical Machines
Safety Razor Machines
Paper Tube Machines
Paper Bag Filling Machines
Button Hole Machines
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Horn-Presses
Rock Drills
Automatic Feeders for Printing Presses
Jigs, Fixtures and Tools to your blue prints

WIRE ROPE

The wires in a Roebling Wire Rope are rolled and drawn from carefully selected metals and are shown by thorough and exacting tests to be strong, pliable and uniform in quality.

These wires are stranded into rope in accordance with designs and shop methods developed from the experience of many years.

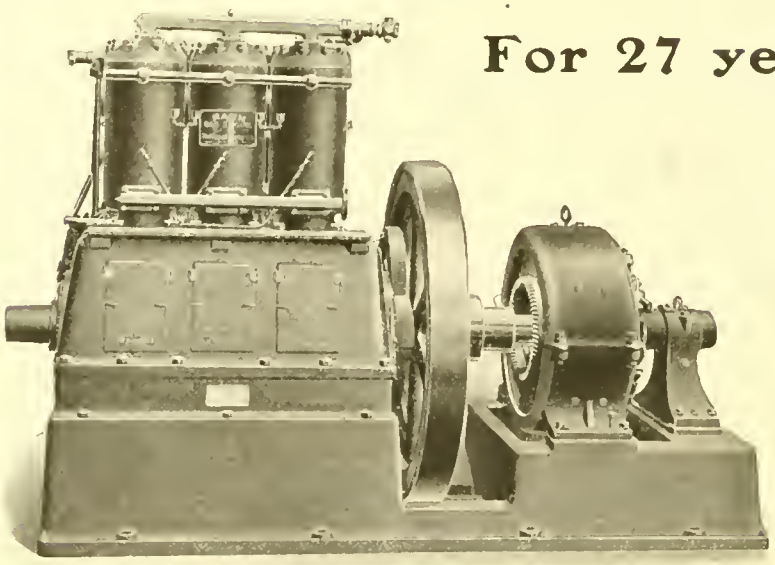
Rope so made will give much more satisfactory and far more durable service than can be obtained from rope composed of lower grade wires or one in which the strands are so laid as to cause unequal stresses and uneven distribution of wear.

Improved Plough Steel Rope, made with a blue center, is recommended as the best rope for extra heavy loads.

John A. Roebling's Sons Co., Trenton, N. J.

Agencies and Branches: New York, Atlanta, Philadelphia, San Francisco, Pittsburgh, Los Angeles, Chicago, Seattle, Cleveland, Portland, Ore.

THE NASH ENGINE



For 27 years the leader in Vertical Gas Engine Design

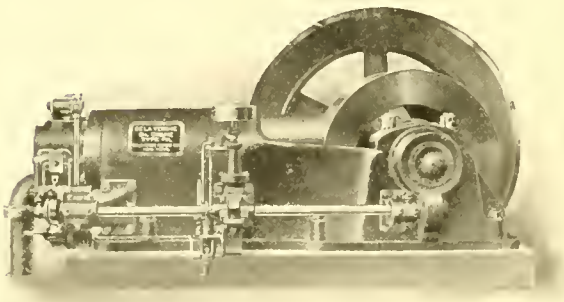
Specially adapted for

Electric Generation
Water Works
and high grade
Power Plants

NATIONAL METER COMPANY

CHICAGO NEW YORK BOSTON

De La Vergne Oil Engines



TYPE FH OIL ENGINE

Send for Bulletin No. 132

Have been developed over a period of twenty years in the United States to meet American conditions.

Heavy Mexican crude oil with sulphur up to 3½% is the cheap American fuel.

Specially trained operating engineers are expensive. The De La Vergne engine has been highly developed and will burn this cheap fuel and operate with only ordinary attention.

We guarantee when operating at three-quarters or full load a fuel consumption of one-half pound ($\frac{1}{16}$ of a gallon) per Brake Horse Power Hour of any commercial fuel or crude oil produced in the United States or Mexico.

The economy, the ability to burn the heaviest fuels and the simplicity of the De La Vergne engine make it the ideal source of power for factory service, electric installations, ice plants and isolated stations of every description.

We build engines from 12 to 800 H. P.

As many as eight successive orders comprising forty-two engines in all, have been placed by a single customer for his own use—proof positive of satisfactory service.

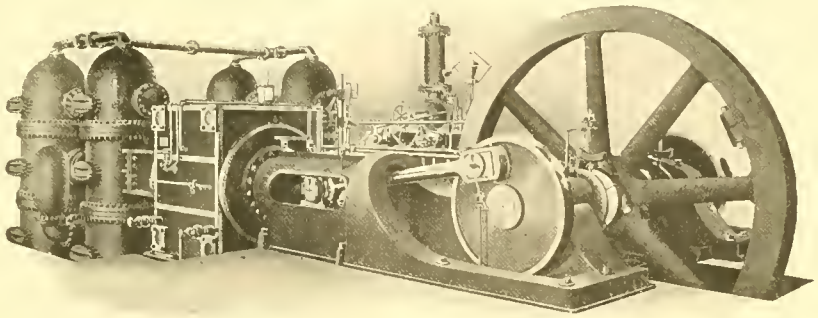
De La Vergne Machine Company

1123 E. 138th Street New York City

HAMILTON CORLISS

Horizontal Crank and Fly Wheel Pumping Engines

are particularly designed for hard service and long life and the valves are arranged in the annealed steel casting decks in such manner that the flow of water is not deflected in all directions, as is necessarily the case when the bee-hive or cage system is used.



Hamilton Corliss Engines are the most economical steam operated prime movers known and are sold on their operating record.

Send for Bulletin "F"

THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO, U. S. A.

GEARS

CUT AND MACHINE MOLDED

AIR FURNACE IRON OPEN HEARTH STEEL
VANADIUM STEEL NICKEL STEEL

ONE RESPONSIBLE FOR MATERIAL AND WORKMANSHIP, BECAUSE WE MAKE ALL GEAR BLANKS IN OUR OWN PLANT.

AS DESIGNERS AND BUILDERS OF COMPLETE GEAR DRIVES, WE HAVE LARGE EXPERIENCE, THE USE OF WHICH IS AT THE SERVICE OF OUR CUSTOMERS.

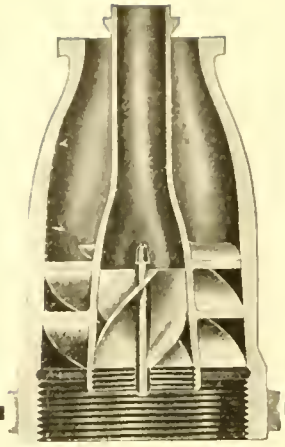
Send for Bulletin "K."

MESTA MACHINE COMPANY

PITTSBURGH, PA , U. S. A.

WORKS:
MESTA STATION, P. R. R., WEST HOMESTEAD, PA.

DESIGNERS AND BUILDERS OF
GAS AND STEAM ENGINES, ROLLING MILL MACHINERY, CONDENSERS, AIR COMPRESSORS, FORGING PRESSES.



RE-COOLING CONDENSING WATER

A high vacuum with the least amount of condensing water is only obtained with condensing water of low temperature, and where purchased from the city or the natural supply is limited, the best means of re-cooling the condensing water, cooling the jacket water of oil or gas engines, etc., is by the use of

Recent installation of Koerting Low Pressure Re-cooling Nozzles at the LOUISVILLE COTTON MILLS, LOUISVILLE, KY.

Koerting Low Pressure MULTI-SPRAY NOZZLES

which is a *double effect nozzle.* It breaks the water up into the finest particles, not like inefficient constructions where a full stream of water mixes with atomized water resulting in big drops. The atomization in the Koerting Multi-Spray Nozzle is perfect.

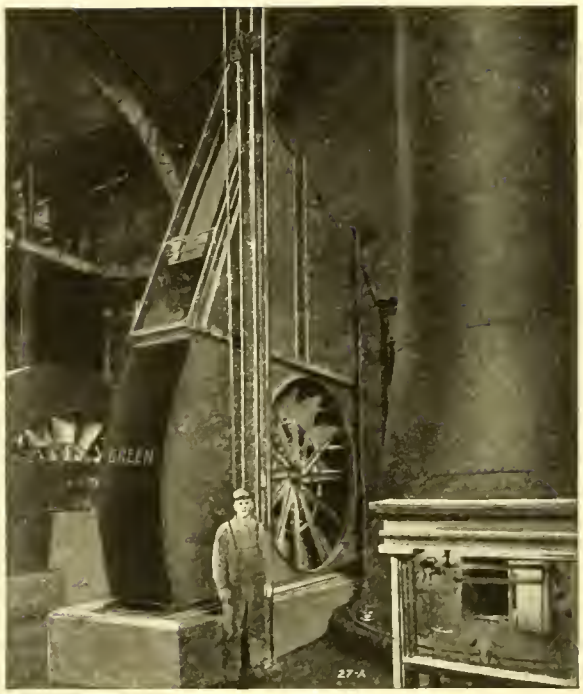
The life of such a spray cooling plant is considerably longer than cooling towers, operation cheaper than cooling towers, and there is little or no cost for repairs.

Write today for a copy of our Catalogue 6-B

SCHUTTE & KOERTING CO.

1239-57 North 12th St. Philadelphia

New York, 50 Church St. Chicago, Security Bldg.
Boston, 132 High St. Pittsburgh, Keenan Bldg.
Denver, 1st Nat. Bank Bldg. Cleveland, New England Bldg.
Kansas City, Burton Machy. Co.



Free Power For The Draft Fan

Designers of steam plants are finding that it is cheaper to install stokers with mechanical draft and operate the boilers at 100% overload or more, rather than to install more boilers and more chimneys. This is good engineering, since it reduces the percentage interest and depreciation charges on boiler equipment and real estate, and the power for driving the draft fans can be obtained free of charge.

To illustrate:—Suppose you have an average plant equipped with under-feed stokers using 60 to 80 lbs. of air per boiler horsepower-hour. The draft through the fire bed will vary from 3 to 5 inches of water according to load, say 4½ inches on the average.

With 80 lbs. of air this figures out to .013 air HP. per boiler HP. generated.

With a Green's Mechanical Forced Draft Fan driven directly by steam turbine, or electric motor if you like, an efficiency of about 60% will be realized, which makes the power of the shaft .02 HP. per boiler HP.

A directly connected turbine driving a high-speed fan will take, say, 35 lbs. of steam per brake HP., or 0.74 lb. of steam per boiler HP. served, that is, less than 2.5% of the total steam production. If the fans are driven by electric motor, receiving current from the main turbine, the steam consumption for the draft will be about ⅓ of this, or not more than 1% of the steam produced.

This may look big if you think of it added to the 3 to 5% required to drive the condenser auxiliaries and the 1 or 2% required for other purposes about a steam plant.

However, do not overlook the fact that if you are using forced draft, the chimney gases need not be at 550 to 600 deg. F., but can profitably be cooled by a Green's Economizer to 250 to 300 deg. F., effecting a saving of 10 to 15% of coal, which will be sufficient to cover the steam consumption of the draft fan and to pay all interest and depreciation charges upon forced draft equipment and economizers, besides leaving a comfortable sum over for pure profit.

Is this not worth going after in view of the fact that you are obtaining twice the capacity without adding to your investment in boilers and real estate?

If interested, send for our Treatise M. E. 108A.

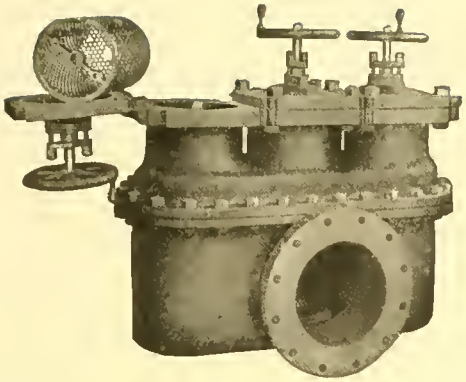
The Green Fuel Economizer Co.

Matteawan, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers: Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines.

(378)



Superior Features *of*

LAGONDA

Multiple Water Strainers

1. With one basket out of service, the remaining baskets have from two to six times greater free straining area than the area of the inlet pipe.

2. Specially designed to reduce friction of flowing water to the minimum.

3. Flow of water continuous and ABSOLUTELY UNINTERRUPTED for the smallest fraction of time, even when changing baskets for cleaning.

4. Valve seats and discs of bronze, which will not rust nor corrode.

5. Foreign matter collecting in baskets settles to the bottom and does not reduce straining area, obstruct the flow of water or change its course. Baskets, therefore, are not subjected to undue wear.

6. Foreign matter is retained in baskets. In cleaning, a few turns of one hand-wheel brings the basket into the cleaning chamber, from which it can be lifted, taken to any convenient point and dumped; no sloppy, dirty mess on the floor or around the machine in this process.

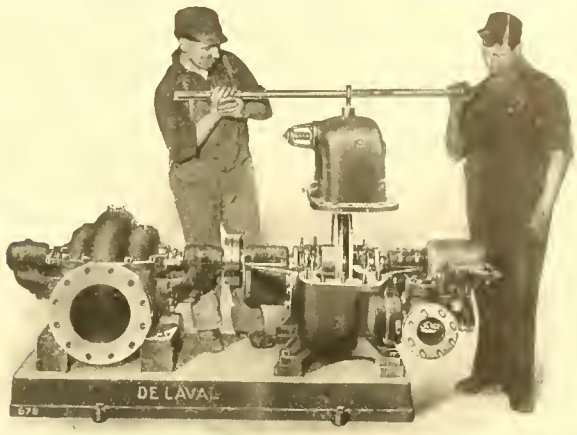
7. Can be installed in either horizontal or vertical line.

8. When installed in horizontal line under the surface, the line can be covered, leaving the top of Strainer accessible without digging a pit around it.

Write for Catalog JR to-day

The Lagonda Mfg. Co.
SPRINGFIELD, OHIO
FUEL SAVING SPECIALISTS
NEW YORK, BOSTON, PHILADELPHIA, ST LOUIS, CHICAGO, DETROIT
DALLAS, SAN FRANCISCO, ST PAUL, MONTREAL, LONDON

Makers of Weinland Boiler Tube Cleaners, Automatic Cut-off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers 194



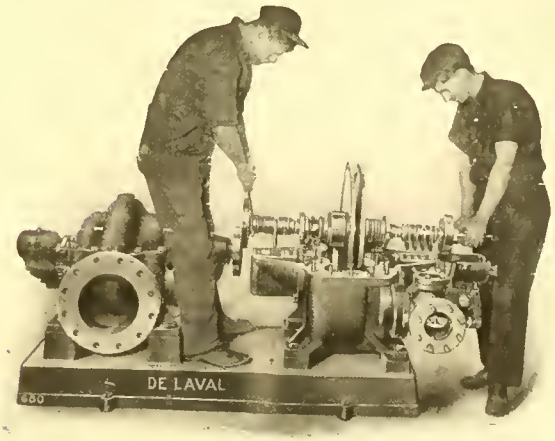
Two men lifting off the casing cover of a 100-horse power DeLaval Class "C" Turbine.

Ease of Renewal of the Wearing Parts of a DeLaval Class "C" Turbine

ALL inspections, changes or repairs can be made without disturbing steam or exhaust connections, without requiring the use of a crane, without the necessity of sliding heavy parts out horizontally, without disassembling the wheels from the shaft or removing internal diaphragms from the casing, and without requiring the services of an expert. The DeLaval Class "C" Turbine is the only turbine on the market meeting all these requirements.

The whole subject of the design of steam turbines for driving steam plant auxiliaries is thoroughly discussed in our book C 58, which will be sent upon request.

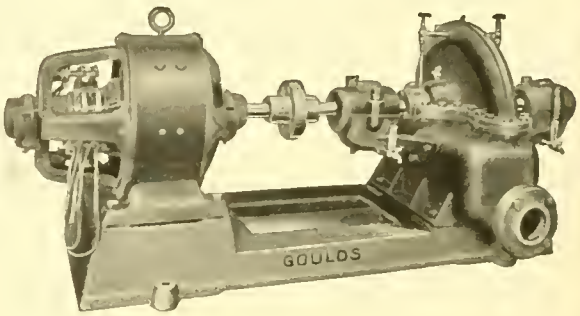
DE LAVAL
STEAM TURBINE CO.
TRENTON, N. J.



Lifting out the rotating member after having removed the bearing caps.

102

There Is Extra Quality In Every Detail of
The Goulds Single-Stage, Double-Suction Centrifugal



The impeller is accurately machined to a smooth finish and is so designed that the highest efficiency is obtained.

Brass water sealing rings prevent air being drawn into the pump at the stuffing boxes and make it unnecessary to draw the glands up tight.

The rotating parts are balanced accurately to insure smooth operation.

All machining is done accurately, and before leaving the factory each pump is carefully adjusted and tested.

Bulletin No. 110 gives detailed information.

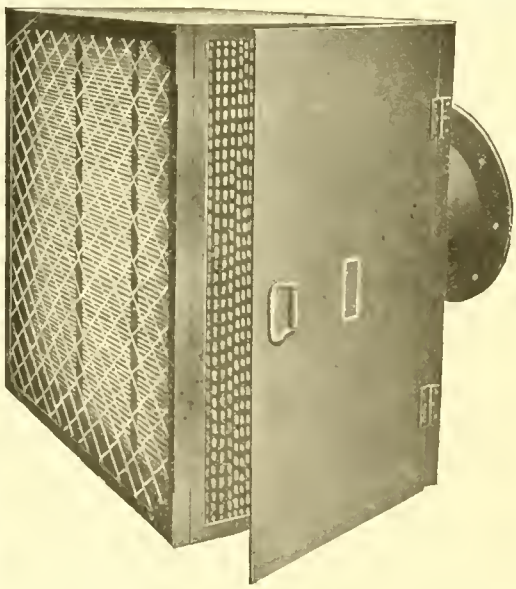
THE GOULDS MFG. CO.

LARGEST MFR. OF PUMPS FOR EVERY SERVICE

78 West Fall Street - - - - - - SENECA FALLS, N. Y.

Branches and Agencies in Principal Cities

GOULDS PUMPS



Air Filtering

A large amount of clean air must necessarily be supplied to Generators, Turbo-Dynamos, Motors, Compressors, etc., in order to keep the windings, bearings, etc., of these high-speed machines cool and free from dust and dirt, and up to their highest efficiency. This is not only desirable, but quite often absolutely necessary when such machinery is located in places where the air is heavily laden with impurities, such as dust and fine dirt.

Dry System :

The Dry System of filtering the air is shown in illustration herewith, and offers a very simple and inexpensive method, as the ventilators of the generators, etc., serve to draw the necessary air through the filter, which consist of a box made of steel plate, inside of which is inserted a number of racks containing the filter material. These racks may be removed separately from time to time for cleaning purposes.

Wet System :

The Wet System consists of a number of atomizing nozzles, installed in a chamber, through which water is forced under pressure, thus washing the air and precipitating all foreign particles, after which the air passes through an eliminator to remove the moisture and thence to the Generators, etc.

FULL INFORMATION ON REQUEST.

GENERAL CONDENSER CO.

1250 N. 12th STREET PHILADELPHIA, PA.

General Condenser Co.
1250 N. 12th St., Philadelphia, Pa.
Please send me full particulars re your Air Filters.

Engineer
Company
Street

I. P. MORRIS COMPANY

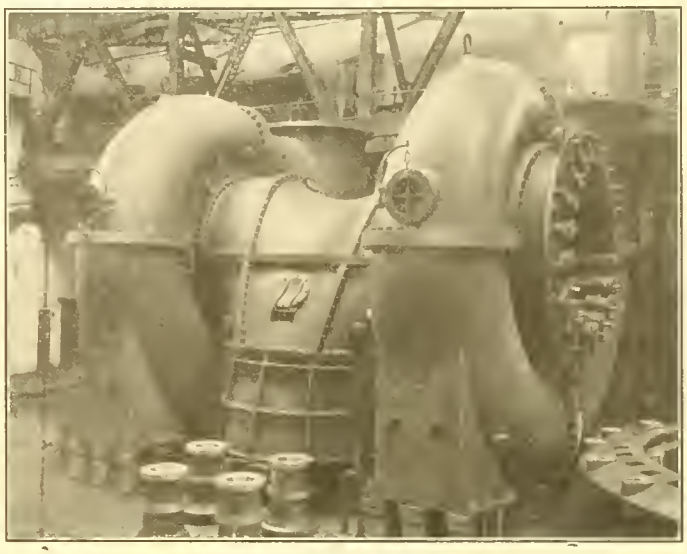
PHILADELPHIA, PA.

Specialists in the Design and Construction of High Class, High Power, and High Efficiency Hydraulic Turbines

The I. P. Morris Company in 1851 built its first hydraulic turbines, which were used continuously by the Water Works Department of Philadelphia until superseded by the present filtration system in 1908.

Total capacity of turbines built or under construction by I. P. Morris Company since it began active construction of hydraulic turbines now aggregate 1,670,000 horse-power.

Inquiries for turbines requiring special design will be given every attention.



22,500 H. P. TURBINE

Two units furnished. Head 168 Feet. Speed 200 R. P. M.
Most Powerful Water Turbines in existence

WESTON

Miniature Precision Instruments for Direct Current

A new group of very small Indicating Instruments
COMPACT — ACCURATE — DURABLE — BEAUTIFUL

MODEL 280, Single Range Portable Voltmeter. (One-quarter Size.)

MODEL 280, Triple Range Portable Volt-Ammeter. (One-quarter Size.)

PORTABLE

Voltmeters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters, are supplied in single, double and triple ranges.
The triple range volt-ammeter comprising six instruments in one. This group also includes BATTERY TESTERS.

SWITCHBOARD

Voltmeters Volt-Ammeters Ammeters Mil-Ammeters

This new line of instruments represents the latest development of the pivoted moving coil, permanent magnet type for low ranges.

The refinement of design and mechanical work in them has been carried to a degree which would appear to be almost impossible of accomplishment, if the results were not evident in the instruments themselves.

They embody characteristics which have made the well known Weston Standards famous throughout the world.
They are accurate, dead beat and extremely sensitive.
They may be left continuously in circuit at full load without injury and are shielded against the external electrical and magnetic influences of other apparatus in their vicinity.
They are substantially constructed and may be safely sent long distances through the mails and will withstand an extraordinary amount of vibration without injury.
They have the longest scale ever provided in instruments with equal length of pointer.
Each model has been thoroughly tested under the most severe conditions of service and in experiments extending over more than one year.
The portable instruments may be conveniently carried in the coat pocket.
The prices have been established upon so low a scale that any one may possess one or more of these remarkable instruments at moderate cost.
If you cannot obtain the instruments desired from your dealer, write us.
The several models and ranges offer a selection from over 300 different combinations, listed in Bulletin No. 8. Will be mailed upon request.

MODEL 267, Switchboard Ammeter. (One-quarter Size)

MODEL 268, Switchboard Volt-Ammeter. Reads Amperes. Press Button for Volts. (One-quarter Size.)

WESTON ELECTRICAL INSTRUMENT COMPANY,

Main Office and Works: NEWARK, N. J.

New York, 114 Liberty St.
Chicago, 832 Monadnock Block.
Boston, 176 Federal St.
Philadelphia, 342 Mint Arcade.
Birmingham, Amer. Trust Bldg.

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Johannesburg, So. Africa, F. Peabody Rice, Standard Bank Buildings, Harrison St.

Opportunity

is accredited in some quarters with but a single knock. While we intend calling as often as necessary, it might prove as advisable to answer one of the initial summons as those later on.

Goodrich LONGLIFE and MAXECON CONVEYOR BELTS

reduce tonnage costs.

We are taking the license of associating our service with the call of opportunity solely through being witness to the economy and efficiency our years of experience in many fields have enabled us to effect. It has been a great satisfaction to serve in this manner those who have honored us with their confidence.

Elevator Belts	Packing
Transmission Belts	Valves
Air Drill Hose	Matting, etc.

The B. F. Goodrich Company

Factories: Akron, Ohio

Branches in All Principal Cities

There is nothing in Goodrich Advertising that isn't in Goodrich Goods

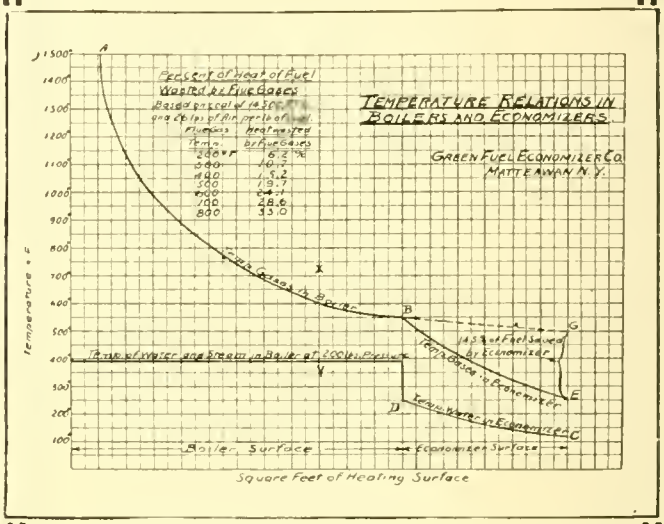
Makers of Goodrich Tires and Everything that's Best in Rubber

One Foot of Economizer Surface

Takes the Place of

Two Feet of Boiler Surface

THE full lines show the relation between the temperature of the gases of combustion passing through a boiler and economizer and the temperature of the water and steam in the boiler and the water in the economizer.



By adding six square feet of Economizer Surface to a boiler containing 12 square feet of surface 14.6% of fuel are saved. This represents average practice, with the gases leaving the boiler at about 550°F. and the economizer at 250°F. the water entering the boiler at 300°F.

However, by cutting 3 sq. ft. off the boiler and adding 1½ sq. ft. to the economizer the same saving is obtained, namely: 14.6% of fuel, but with 1½ sq. ft. less total heating surface. In this case, the gases leave the boiler at 700°F. and leave the Economizer at 250°F. as before, while the water enters the boiler at 350°F. instead of 300°F. the initial temperature of the water being 120°F. in each case.

The increased activity of the heating surface as a whole, in the second case, is due to the fact that the average temperature difference between gases and water is greater in the economizer than in the boiler, hence, substituting Economizer for boiler surface leads to an increase in the average activity of the heating surface. The net saving in first cost is about $2.00 for each boiler horse power developed. Is not this worth looking into when you are designing a boiler plant?

Write for our new 100-page Economizer Catalog M. E. 142, in which the theory of boiler and economizer is more fully explained

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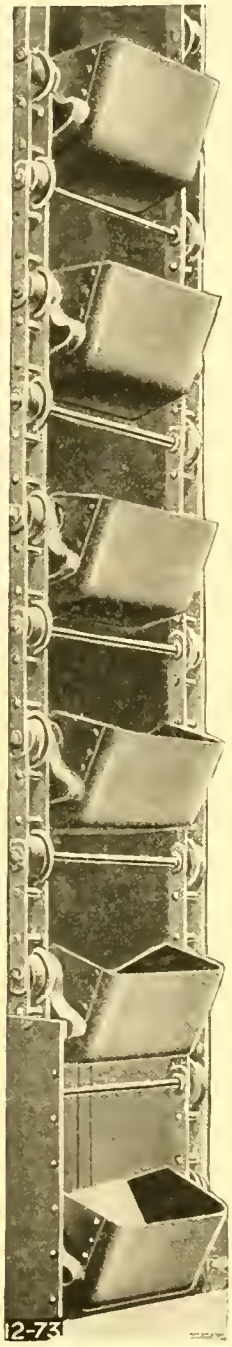
Engineers; Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines.

363

HUNT
Noiseless Conveyors



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are silently elevating and conveying thousands of tons of coal, fertilizer material, phosphate rock, ashes and even "Tomatoes" in most every part of the world—and doing it so efficiently and with so little "fuss" that in many plants they hardly know such a machine is in operation.

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This Conveyor is made in sizes, and the buckets of material, to suit any conditions. If you have bulk material of *any* kind to handle—tell us your problem and let us help you solve it. Anyway, write for Catalog S-12-9. It's free and it's interesting.

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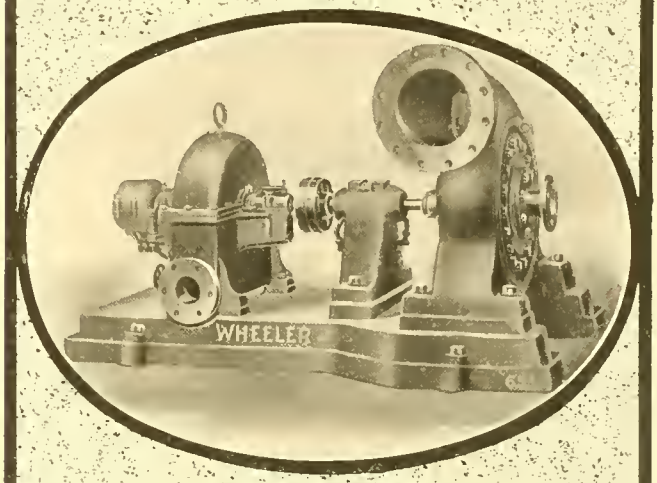

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Large free air capacity
Turbine or motor drive
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Small floor space
Simplicity
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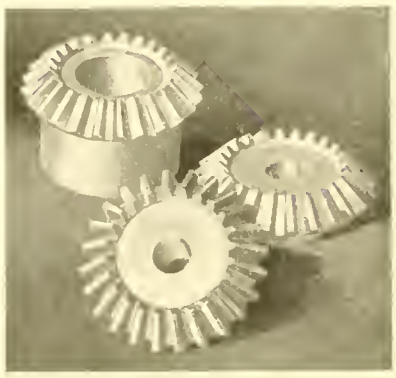

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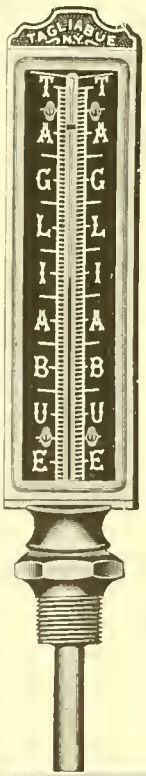

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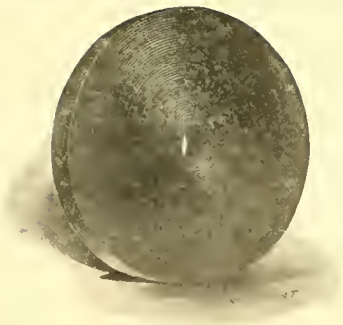

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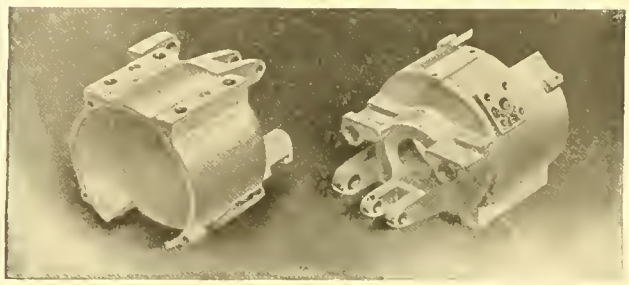

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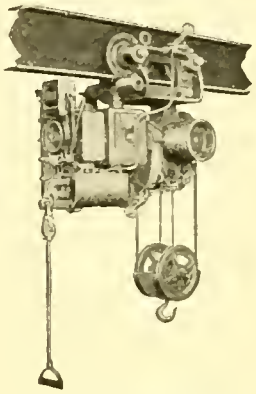

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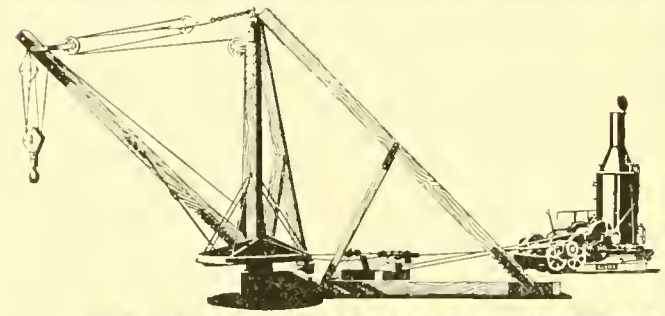

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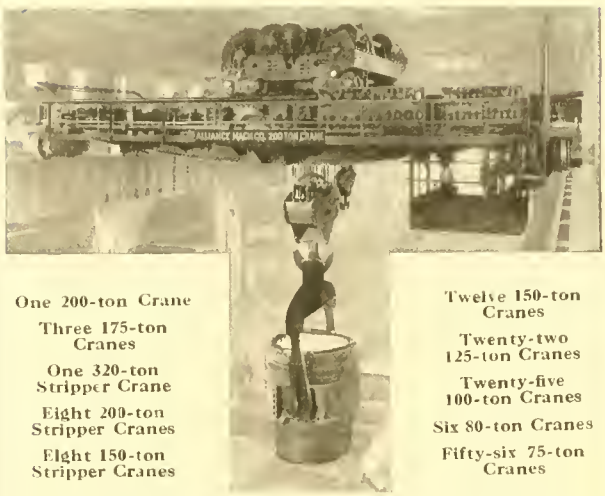

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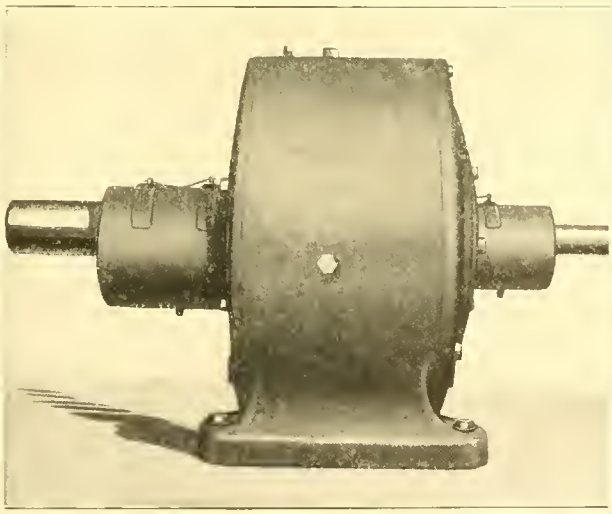

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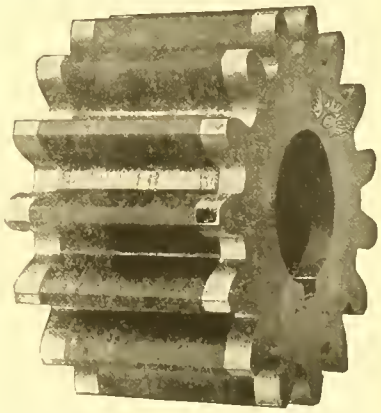

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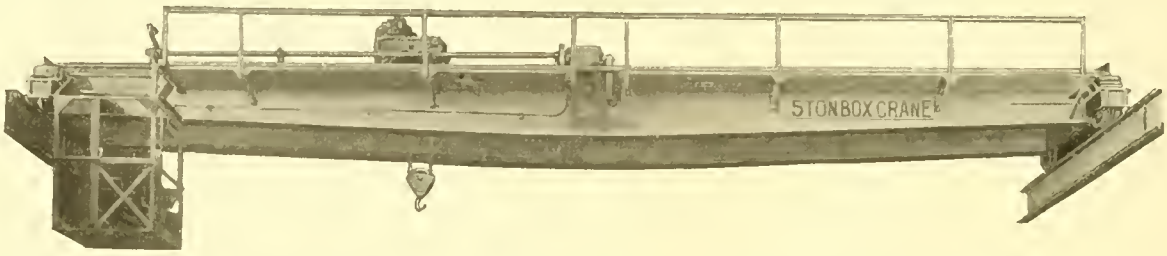

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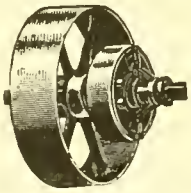

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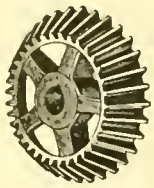

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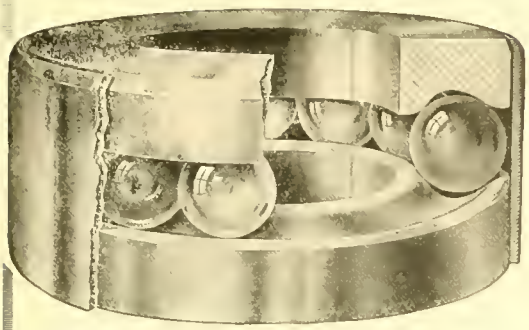

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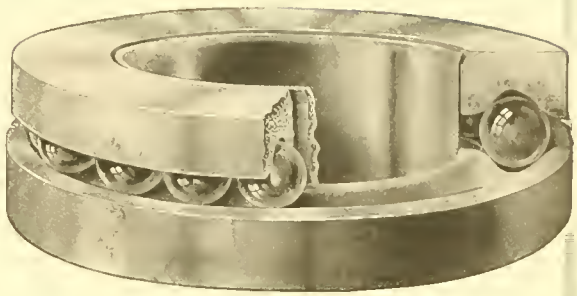

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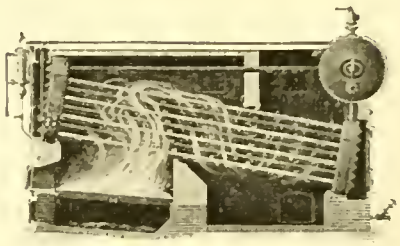

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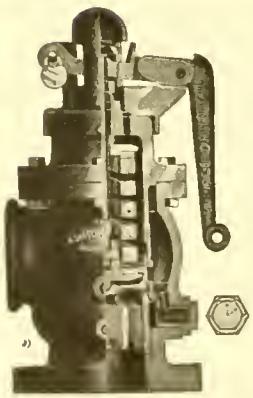

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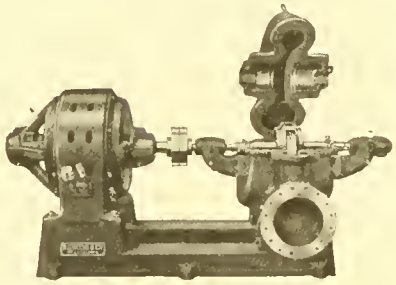

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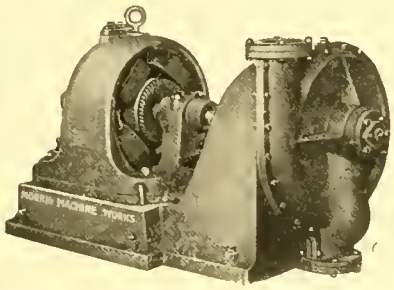

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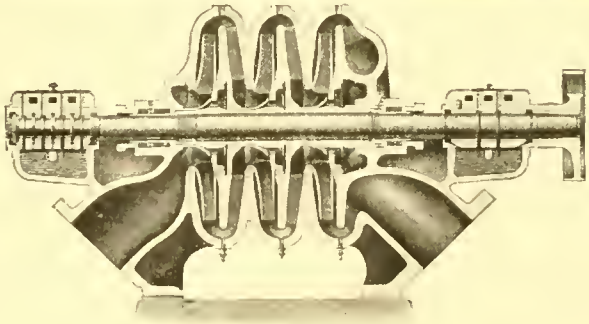

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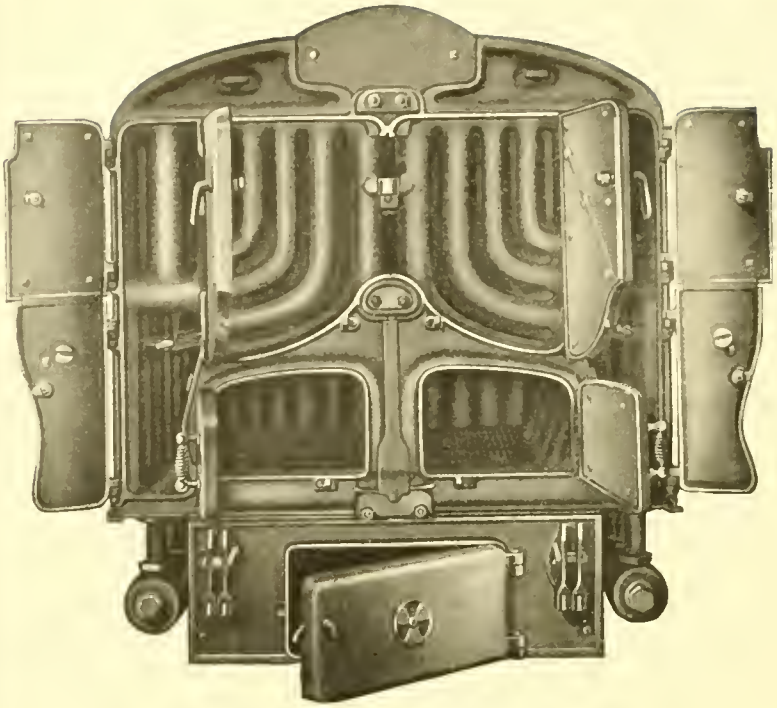

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Builders of the Edge Moor Water Tube Boiler. Especially suitable for large power plants. Steel construction, straight tubes, all hand holes elliptical, unrestricted circulation which permits forcing fires with safety and economy.

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Manufacturers of Fleming-Harrisburg Horizontal Engines, Corliss and Single Valve, Simple, Tandem and Cross Compound.

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HEINE SAFETY BOILER CO.

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HAMILTON, OHIO

Manufacturers of Hamilton Corliss Engines, Hamilton High Speed Corliss Engines, High Duty Pumping Engines, Power Pumps and Compressors, Special Heavy Castings.

See pages 6, 7, 309 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Compressors

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Water Tube, Internal Furnace and Return Tubular Boilers. Self-Supporting Stacks, Feed Water Heaters.

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PROVIDENCE, R. I.

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No. 1071. Influence of the Connecting Rod Upon Engine Forces: S. A. Moss, price $0.10; No. 922. Effect of Clearance on Economy of Steam Engine: A. Kingsbury, price $0.10; No. 873. Comparison of Rules for Calculating the Strength of Steam Boilers: H. de B. Parsons, price $0.10; No. 819. Boiler and Furnace Efficiency: R. S. Hale, price $0.30.

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Manufacturers of Corliss and Medium Speed Engines, Fulton-Tosi Oil Engines Diesel System, Cane Sugar Mills and Crushers.

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Builders of Smith Automatic Gas Producers, both suction and pressure types. Mechanically Operated Gas Producers in large units for power and heating plants. Tar Extractors and Gas Cleaning Plants.

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Complete Condensing Plants for High Vacuum; Counter Current, Jet and Surface Condensers, Air Pumps, Pumping Outfits, Re-Cooling Plants. Oil, Air and Steam Separators. Combined Oil Separators and Heaters. Dry and Wet Air Filters. Air Extractors for Feed Water ("Airex"). Return and Vacuum Steam Traps.

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Green Chain Grate Stokers for free burning and coking bituminous coals. GECO Pneumatic Ash Handling Systems.

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Fuel Economizers; Waste Air Heaters; Fans, Blowers and Exhausters; Engines; Positivflow Hot Blast Heaters, Drying Equipments; Heating and Ventilating Equipments, Mechanical Draft Installations.

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Makers of Weinland Tube Cleaners, Automatic Cut-Off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers.

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Manufacturers of genuine Ludlow Gate Valves for all purposes. Special Blow-off Valves. Check Valves. Foot Valves. Sluice Gates. Indicator Posts. Fire Hydrants.

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CINCINNATI, OHIO

Manufacturers of high-grade engineering specialties, comprising Brass and Iron Valves, Whistles, Cocks, Gauges, Injectors, Lubricators, Oil Pumps, Oil and Grease Cups, etc., adapted to the requirements of all classes of machinery.

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Return, Non-Return, Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

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Builders of The Murphy Automatic Furnace. The best Automatic Furnace that thirty years practical experience can produce.

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Chestnut Hill PHILADELPHIA, PA

Manufacturers of high grade Bronze, Iron and Steel Valves of every kind for every purpose.

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THE PICKERING GOVERNOR CO.

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Governors for Steam Engines, Turbines, Gas Engines. Mechanical Control Power Regulation.

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Governors

POWER SPECIALTY CO.

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The Foster Patent Superheater saves feed water, condensing water, coal and boiler power.

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Superheaters

PAPERS PUBLISHED BY A. S. M. E.

No. 1214. Unnecessary Losses in Firing Fuel Coal: C. R. Weymouth, price $0.30; No. 1213. Fuel Economy Tests at a Large Oil Burning Electric Plant: C. R. Weymouth, price $0.20; No. 1165. The Rational Utilization of Low Grade Fuels in Gas Producers: F. E. Junge, price $0.40; No. 1245. Some Properties of Steam: R. C. H. Heck, price $0.10.

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Manufacturers of Brass, Iron and Steel Valves, Fire Hydrants, Asbestos Packed Cocks.

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Injectors, Syphons, Eductors, Furnace Blowers, Exhausters, Pump Primers, Condensers, Spray Cooling Nozzles; Valves; Small Brass and Iron Body, Open Hearth Steel-Stop, Stop Check, Emergency Stop Check, Trip, Throttle Trip, Engine Stops, Steam Traps, Feed Water Heaters, etc.

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Manufacturers of Instruments for Indicating, Recording and Controlling Temperature and Pressure. Thermometers; Automatic Controllers; Gages; Oil Testing Instruments; Engineers' Testing Sets, Pyrometers, Barometers, Hygrometers, Hydrometers, etc.

See Page 132 of Condensed Catalogues of Mechanical Equipment.

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Lubricating Oils for Power Plants, Central Stations, Machine Shops, Foundries and all general purposes. All classes of Petroleum Products of the highest quality.

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MAIN OFFICE AND WORKS: CARTERET, N. J.

Surface, Jet and Barometric Condensers, Combined Surface Condensers and Feed Water Heaters, Cooling Towers, Edwards Air Pumps, Centrifugal Pumps, Rotative Dry Vacuum Pumps and Multiple Effect and Evaporating Machinery.

See page 66, 67 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Condensers

Cooling Towers

Feed-Water Heaters

C. H. WHEELER MFG. CO.

PHILADELPHIA, PA.
NEW YORK BOSTON
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Manufacturers of High Vacuum Apparatus, Condensers, Air Pumps, Feed-Water Heaters, Water Cooling Towers, Boiler Feed and Pressure Pumps.

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Water Meters

Blow-off Valves

Pipe-Joint Clamps

YARNALL-WARING CO.

CHESTNUT HILL PHILADELPHIA, PA.

Manufacturers of the "Lea" V-Notch Recording Meter, Simplex Seatless Blow-off Valve and the Simplex Pipe-Joint Clamp.

See page 95 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Papers on Power Plant Specialties

PAPERS PUBLISHED BY A. S. M. E.

No. 1085. Performance of a Superheater: A. Bement, price $0.10; No. 1070. A Twist Drill Dynamometer: H. P. Fairfield, price $0.10; No. 921. The Bursting of Small Cast Iron Fly-Wheels: C. H. Benjamin, price $0.20; No. 1111. Balancing of Pumping Engines: A. F. Nagle, price $0.10.

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The American Pulley. The first all steel parting belt pulley made. Now sold in larger quantities than any one make of pulley. No key, no set screw, no slip; light, true and amply strong for double belts. 120 stocks carried in the United States.

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Pulleys

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22 Elizabeth St. ROCHESTER, N. Y.

Auburn Four Point Contact Cone Principle Ball Thrust Bearings, Auburn Special Ball Thrust Bearings, Auburn Steel, Brass and Bronze Balls, Solid and Hollow.

See page 161 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Ball Bearings

THE A. & F. BROWN CO.
79 Barclay St. NEW YORK

Manufacturers of Shafting, Pulleys, Hangers, etc., for Transmission of Power.

See page 148 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Shafting
Pulleys
Hangers

DODGE MANUFACTURING CO.
MISHAWAKA, IND.

Manufacturers of everything for the Mechanical Transmission of Power; also Elevating and Conveying machinery, and the "Eureka" Water Softener. Our new catalog 106A14 gives an idea of the Dodge line.

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High grade Ball Bearings made of the finest materials to the closest standards of accuracy in the world. Fafnir Ball Bearing Hanger Boxes can be used in any standard hanger frame.

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Friction Clutch Pulleys, Couplings, Quills, Operators, Clutch Sheaves, Floor Stands, Heavy Mill Bearings, Shaft Couplings, Sheaves and Tension Carriages, Pulleys and Fly Wheels.

See page 149 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Power Transmission Appliances

THE HILL CLUTCH COMPANY
CLEVELAND, OHIO

Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

See page 156 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West 39th Street, New York

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

INCLUDING THE TRANSACTIONS OF THE SOCIETY

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

APRIL · 1914

SPRING MEETING, ST. PAUL-MINNEAPOLIS

JUNE 16-19

One's Contribution to His Profession

Of the many privileges which the Society offers to its membership none is more valuable than the opportunity of participating in the broad work which it is doing for the advancement of the Engineering Profession.

Everyone associated with the engineering profession should give his active support and interest in furthering its welfare. The ultimate result of combined coöperation would be to increase the respect for the engineering profession and accord it the same degree of esteem which is given to the other professions.

The newer members of the profession may join with their more experienced colleagues in this general development and if the spirit with which each one enters into the work is sincere and unselfish, there is no doubt of the enhancement of the standing of the professional engineer.

The engineer who joins the Society with the idea of taking an active part in its affairs and contributing to its general welfare in every way possible, will in the long run receive a substantial return on his investment.

Some may say, "I believe all that you say, but what can I do?"

First, it is hoped the members will offer their experience in the form of papers to be presented before the various meetings of the Society; second, serve on the various committees now active or new ones to be developed, at least write in and say you are interested; third, if you yourself have not the material for a paper it is probable you know who has and can advise us, or you may want information. The latter request is valuable as it enables us to serve your wants. Fourth, by securing the addition to the Society of other well qualified engineers and executive officials of large industrial enterprises who may by increased influence still further dignify our calling by doing everything possible to promote and maintain the ethics of the profession.

Total Membership of Society, March 15, 1914 ..... *5445*

New Members since January 1, 1914 ..... *74*

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 APRIL 1914 Number 4

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C 55. The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

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COMING MEETINGS OF THE SOCIETY

April 8, *Boston, Mass.*, Engineers Club. Subject: Small Package Conveyors with Reference to Industrial Plants. Papers: Selective Types of Conveyors, W. O. Hildreth, Lamson Company; Pneumatic Despatch Tubes, F. B. Williams, Lamson Company; Machinery for Handling Small Packages, S. L. Haines, Link-Belt Company.

April 10, *Buffalo, N. Y.* Address: Impressions of Industrial Germany, L. P. Breckenridge.

April 14, *New York City*, Engineering Societies Building. Paper: Graphic Statistics for the Engineer and the Executive, Willard C. Brinton.

April 29, *Providence, R. I.*, Masonic Hall. Joint Dinner of the Providence Association of Mechanical Engineers and the Society. Biograph lecture on The Manufacture of Wrought Pipe, from the Ore to the Finished Product, by Harold T. Miller, National Tube Company, Pittsburgh, Pa. Tickets, $2 each.

May 1, *New Haven, Conn.*, Mason Laboratory, Sheffield Scientific School. Quarterly meeting with sessions at 3 p.m. and 8 p.m. Subject: Internal-Combustion Motors as Applied to Aeroplanes and Automobiles.

May 5, *San Francisco, Cal.* Subject: Stationary Diesel Engine Operation using California Fuel Oil.

Spring Meeting, June 16–19, *St. Paul-Minneapolis.* See pp. III and XIII.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

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THE SPRING MEETING

The Society is fortunate in its choice of location for the Spring Meeting to be held in St. Paul-Minneapolis on June 16 to 19. St. Paul, with its picturesque location and historic interest, is a most attractive city, and Minneapolis, although the great manufacturing center of the Northwest, is also one of the beautiful cities of the country. The picturesqueness of these cities and the attractions which they will inevitably have for the members who will attend this meeting are suggested in the collection of views shown elsewhere in this number.

The local committee in St. Paul and Minneapolis are making special efforts to arrange an attractive program of entertainment with opportunities for the inspection of the many interesting engineering features of that part of the country.

As at present arranged, the program is as follows: On the two opening days the meetings will be held in St. Paul, beginning with a reception on the evening of June 16. Mr. James Hartness, President of the Society, will make introductory remarks, which will be followed by a message to the engineering fraternity by Mr. James J. Hill, former president of the Great Northern System. Dancing will conclude the evening.

Wednesday morning, June 17, will open with a business meeting, to be followed by a professional session. The ladies will be shown about the city and will be entertained at luncheon. The afternoon will be devoted to a second professional session.

The Thursday morning session will be held in Minneapolis in the buildings of the University of Minnesota. A representative of the University will make the opening address, and luncheon will be served. During the morning the ladies will be shown about the city in automobiles. In the afternoon the members of the Society and their guests will be entertained by Mr. Gebhard Bohn at his beautiful home on Lake Minnetonka. Supper will be served and dancing will follow.

Friday will be devoted to technical excursions. There is a prospect of a trip to Duluth, in which case it is recommended that the party leave at 2.30 p.m., arriving in Duluth at 7.00 p.m., where a reception will be tendered by the local members of the Society. An opportunity will be given next day to inspect the Duluth harbor with all its engineering features. It is hoped that boat connections will be such that members from the East may return by way of the Lakes.

A further suggestion is a trip to Keokuk to inspect the great water-power plant on the Mississippi River.

ENGINEERING DATA IN CONVENIENT FORM

Nobody unconnected in some way with its production, presentation, or preservation, realizes the extent of the increase in the rate of output of technical literature. The increasing number of researches undertaken by institutions of learning, professional committees, endowed laboratories and individual observers, the increasing number of papers presented to the always growing number of societies, the inducements offered by the publishers of books and periodicals, the data furnished by builders and purveyors of various apparatus, have resulted in a flood of technical literature which few have the capacity to pass and filter. It is a serious task upon one's time to read everything which appears, even relating to his own profession, and the specialist must confine his study and his accumulation of material to his own subject, or be swamped.

In the early days of the Society mechanical engineering was in itself quite a specific specialization, and the result of a year's activities could be adequately presented in a volume of reasonable size and cost. These volumes form an imposing array upon the bookshelves of many of the members, but occupy an exorbitant amount of space in proportion to the number of usable references which they contain.

With the advent of The Journal the Transactions became a duplication in presentation. Papers presented to the Society were published in The Journal previous to the meeting, and in the Transactions at the end of the year. The extra presentation in Transactions will cost $11,000 this year, and would

probably cost $15,000 next time if continued, on account of the fact that two volumes would be required. It appeared preferable to the Publication Committee:

a To print the papers separately, as usual, for distribution before the meeting.

b To make The Journal's treatment of the papers and the meetings a readable account of what they contain and accomplish.

c To bind the papers separately in paper covers, each with its discussions, rather than to bind them all together in the Transactions.

Members will be advised in The Journal of the papers which are to be presented at a coming meeting, and can obtain gratis copies of any or all of them by addressing the Secretary. They will thus have in The Journal (*a*) a copy of each paper in full or in abstract, and (*b*) an account of its presentation at the meeting, and of the discussion which it brought forth; and in addition they can have upon request (*c*) complete finished copies of the papers neatly bound with their discussions, and at a very low cost. It is believed that eventually these papers can be supplied to members requesting them free of expense.

A member who wants to keep the Transactions as he has been doing can simply request a copy of each paper presented during the year with its discussions, and get them bound in the style of former years. Those who want to specialize more can order the papers in which they are especially interested, and bind or file them as they see fit. Papers upon the same or similar subjects can be bound together into monographs or symposiums, and in addition the members can bind their Journals if they wish either in whole or in part, provision having been made in the paging for eliminating conveniently the several departments and the matter of merely present or passing interest.

COUNCIL NOTES

At the meeting of the Council on March 13 it was voted to approve the appointment of a Committee to consider and report to the Council standards for presenting graphically engineering data, tests, reports, etc., Willard C. Brinton, Chairman.

It was also voted to take such action as is necessary for the formation of a Standing Committee on Engineering Standards.

H. G. Stott, chairman of the Committee on Flanges, stated that he had attended the conference held in Washington on March 7, called by the Master Steam and Hot Water Fitters Association. Mr. Stott reported that the 1914 American Standard was adopted, with the exception of a few minor points, which it is hoped may be reconciled at a conference to be held very shortly between the committees of the Society, the Manufacturers' Association, and the Master Steam and Hot Water Fitters Association.

Calvin W. Rice, *Secretary.*

LOCAL MEETINGS

A number of interesting meetings are scheduled for local centers during the Spring months, showing the widespread activity of the Society throughout the various sections of the country. All members of the Society are invited to attend all such meetings wherever held.

Regular monthly meetings are to be held in Boston, Buffalo and New York. That in Boston, on April 8, will discuss the subject of Small Package Conveyors with reference to Industrial Plants, with three papers to be presented: Selective Types of Conveyors, by W. O. Hildreth of the Lamson Company; Pneumatic Despatch Tubes, by F. B. Williams of the Lamson Company, and Machinery for Handling Small Packages, by S. L. Haines of the Link-Belt Company. In Buffalo on April 10, Prof. L. P. Breckenridge will make an address on Impressions of Industrial Germany. Willard C. Brinton will read a paper before the New York meeting on April 14 on Graphic Statistics for the Engineer and the Executive, in which he will cover some of the graphic methods not generally used by engineers, but which could be of very great assistance to men who must frequently boil down and abstract information and write reports. Such methods are in use by the biologist and statistician, and they could have wide application in the work of the engineer if more generally understood. Methods for keeping corporation operation records in convenient form for quick reference will be discussed.

The quarterly meeting of the New Haven members will be held in the Mason Laboratory of Mechanical Engineering, Sheffield Scientific School, on Friday, May 1, and will, as usual, have afternoon and evening sessions. Internal Combustion Engines as applied to Aeroplanes and Automobiles will be the subject, and the program is now being arranged. In San Francisco there will be a meeting on May 5 and, following the custom of considering topics of local importance, the subject will be Stationary Diesel Engine Operation using California Fuel Oil. These meetings are usually in the nature of a topical discussion, with one or two brief leading discussions to open the meeting.

The Providence Association of Mechanical Engineers, which is affiliated with the Society, will hold a joint dinner at Masonic Hall in Providence on April 29. A reception will be held at 6 o'clock, with dinner at 6.30. Prof. Wm. H. Kenerson will act as toastmaster, and there will be addresses by James Hartness and Calvin W. Rice, President and Secretary of the Society. A biograph lecture by Harold T. Miller of the National Tube Company of Pittsburgh, on Wrought Iron from the Ore to the finished Product, will follow these addresses. The March meeting was the last held in Philadelphia for the season and the April meeting the final one in New York.

TWO ENGINEERING CONGRESSES

INTERNATIONAL ENGINEERING CONGRESS

San Francisco, 1915

To be held under the auspices of the five national engineering societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Society of Naval Architects and Marine Engineers.

Every engineer is invited to participate in the International Engineering Congress, to be held in San Francisco, Cal., September 20-25, 1915, in connection with the Panama-Pacific International Exposition, and under the auspices of the five national engineering societies.

The Congress has two distinct purposes: (1) The gathering together of a large and representative body of engineers from all civilized countries, with the opportunities which this will present of forming or renewing personal acquaintances, and of interchanging views on the various phases of professional work; and (2) the reading and discussion of papers before the various sections and their later publication in such form as to constitute a valuable addition to any engineering library.

In scope and character, it is intended that the Congress shall be truly international and that it shall embrace in a thorough and comprehensive manner the various branches of the engineering profession. Eminent engineers throughout the world are being invited to contribute papers on assigned topics, and in the selection and distribution of these topics the committee is using its best endeavors to render the series of papers widely representative of the world's best engineering practice in its various branches.

There will be 11 general sessions, the proceedings of which will probably appear in 10 volumes of about 500 pages each, with one smaller or half volume, which will contain the general or business meetings, together with a title and author index and a brief digest of each paper presented.

The general fee for membership in the Congress is $5. This will entitle the member to receive the index volume and any single volume of the transactions which he may select, together with the right of participation in all the general activities of the Congress. All who are interested are invited to become members whether or not they may be able to attend the Congress, so that they may secure the very valuable proceedings for their libraries. Thus far 252 of our membership have enrolled.

In connection with the Congress, the Society looks forward with special anticipation to greeting again the many members of the engineering profession in Europe who made possible the two recent pleasurable trips abroad, in 1910 and 1913. H. L. Gantt has been appointed chairman of a reception committee.

INTERNATIONAL ELECTRICAL CONGRESS

San Francisco, 1915

To be held under the auspices of the American Institute of Electrical Engineers, in conjunction with the Panama-Pacific International Exposition.

There have been ten electrical congresses of international scope, three of which have been held in America. The Conference of Electricians in 1884 was held in Philadelphia. The International Electrical Congress of 1893 was held in conjunction with the World's Columbian Exposition at Chicago. The Congress of 1904 met in St. Louis during the Louisiana Purchase Exposition. These congresses were notable among the many gatherings of international importance at these expositions.

The International Electrical Congress, San Francisco, 1915, is to be held in conjunction with the Panama-Pacific International Exposition, which will celebrate in a fitting manner the completion and opening of the Panama Canal. As this crowning achievement of science and engineering is certain to attract many engineers to the Canal and to the Exposition, it was early recognized that conditions would be propitious for convening electrical engineers of all countries in a congress in which the international feature would be unusually prominent.

One purpose of the forthcoming Congress is to bring together in San Francisco a large and representative body of electrical engineers from all over the world who shall find interest and inspiration in the Congress, in the Exposition, and in the celebration of the completion of the American inter-oceanic canal. A second purpose is to erect in its published transactions a notable milestone of electrical engineering progress and development as a permanent record of contemporaneous electrotechnical achievement.

The membership of the memorable St. Louis Congress in 1904 was over 2000 and the transactions included 150 papers with discussions. The immense growth of the electrical industry and the rapid progress of electrical science during the past decade justify expectations of a much larger membership and of greatly enlarged and even more authoritative and useful proceedings. The published transactions which are expected to constitute a very valuable addition to the literature of the art will be available to members at such a low price, that either in part or as complete sets they will be within reach of all. Those who may be able to attend the Congress may find a large measure of participation through possession of the transactions.

A TRIBUTE TO THE ENGINEERING PROFESSION

Many tributes to the engineering profession were recently paid in the honors shown to Col. George W. Goethals, U.S.N., builder of the Panama Canal, during his late visit to the United States. Notable among these was the presentation of the gold medal of the National Geographic Society at its annual banquet in Washington, on March 3, by President Wilson, who spoke of the nation-wide appreciation of the accomplishments of Colonel Goethals and of the important part of the engineer in the world's work. He said in part:

"The engineering profession is one of the few creative professions. Those of us who have attempted to be literary men conceive that we have created conceptions of the mind, but we never can produce them in court. They are never visibly on exhibition. But the magic of the engineer is that he can change the face of nature and show the work of his hands, and that it is in some deep sense creative in character. The life of mankind on the globe, for example, is altered by the cutting and the use of the Panama Canal.

We have, therefore, to honor the greatest living representative of this extraordinary profession. It seems to me to be natural . . . that the greatest engineer should come from the United States. The United States has made the world very uncomfortable, but it has at least done so by the exercise of extraordinary dynamic qualities. It is not one of the static nations of the world. It is one of the nations which has disturbed equilibrium, which has cut new paths for the thought and action of mankind. . . . We are merely acknowledging the presiding character and genius which drew all the elements of this work together, which made it a work done by colaborers—work done as if it were the conception of a single mind, and work done in the spirit of service and self-effacement, which belongs to a great service of a great government. There is nothing selfish in the eminence of Colonel Goethals. It is representative of a great profession; it is representative of a great government; it is representative of a great spirit."

A photograph of the medal is reproduced on another page of this issue.

At a meeting held in Carnegie Hall in New York City, the Civic Forum also presented a medal to Colonel Goethals, Dr. John H. Finley, head of the New York State Board of Education, making the speech of presentation. A poem in celebration of his accomplishments was written for the occasion by Percy MacKaye, and was read by its author. The following stanzas quoted from it show the tribute paid to the task of the engineer:

"A man went down to Panama
  Where many a man had died
To slit the sliding mountains
  And lift the eternal tide:
A man stood up in Panama,
  And the mountains stood aside.

. . . .

The reek of fevered ages rose
  From poisoned jungle and strand,
Where the crumbling wrecks of failure
  Lay sunk in the torrid sand—
Derelicts of old desperate hopes
  And venal contraband:

Till a mind glowed white through the yellow mist
  And purged the poison-mould,
And the wrecks rose up in labor,
  And the fevers' knell was tolled,
And the keen mind cut the world-divide,
  Untarnished by world gold:

For a poet wrought in Panama
  With a continent for his theme,
And he wrote with flood and fire
  To forge a planet's dream,
And the derricks rang his dithyrambs
  And his stanzas roared in steam.

. . . .

Where old Balboa bent his gaze
  He leads the liners through,
And the Horn that tossed Magellan
  Bellows a far halloo,
For where the navies never sailed
  Steamed Goethals and his crew.

GEORGE WESTINGHOUSE

No characterization of George Westinghouse could be more inclusive and complete than the single sentence uttered at a gathering in London by his intimate friend, the late Lord Kelvin, that "George Westinghouse is in character and achievements one of the great men of our time."

In another part of The Journal is a statement of the notable achievements of the professional career of Mr. Westinghouse which already are a matter of common knowledge as a vital part of the industrial history of the country. The other element mentioned by Lord Kelvin, that of the strength and fine qualities of his character, was equally admired by all his close friends, his workmen and subordinates, and his business associates.

Of the many remarkable qualities that come to one's mind in thinking of Mr. Westinghouse, none stand out more prominently than those which characterized him in his home life.

When separated from Mrs. Westinghouse, as he usually was for two or three days of each week, it was his uniform habit to hold a daily conversation over the telephone. It made no difference how far separated or how busy Mr. Westinghouse may have been, that greeting was exchanged not only at a definite hour, but with fondness and thought of every detail of Mrs. Westinghouse's comfort. Another beautiful feature of the conversation was the never-failing inquiry on the part of both for the guests of the other and the sending of messages of greeting for the guests.

Mr. Westinghouse had the most perfect balance

between strength and gentleness, both physical and mental, of anyone I ever knew. In fact, one might say he had the gentleness of strength under complete control.

Col. E. D. Meier, Past-President of the Society, has written that George Westinghouse "made 'Safety First' possible on railways long before that phrase was coined. His high ethical standards as an engineer, his splendid courage as a manufacturer, his limitless capacity for hard work, made him a hero in the never ending strife for the control of the forces of nature for the service of man."[1]

The funeral services held in the Fifth Avenue Presbyterian Church, New York City, were attended by a great throng of friends and admirers. Rev. S. J. Fisher, D.D., of Pittsburgh, who had known Mr. Westinghouse since as young men they had lived together in Pittsburgh, spoke of Mr. Westinghouse's life from his own personal knowledge. He paid a sincere tribute to his work and character, describing him as one who "walked in the full light of the world, every characteristic open, every phase of his life seen; nothing secret and nothing hidden." H. L. Gantt, Dr. Alex. T. Humphreys and S. T. Wellman, another life long friend since boyhood, represented the Society as honorary pall bearers, and other officers and members of the Society were in attendance.

At the last meeting of the Council a special committee, consisting of Jesse M. Smith and Dr. Alex. C. Humphreys, was appointed to draw up resolutions on the death of Mr. Westinghouse and these will be sent to the family. They read as follows:

"The Council and members of The American Society of Mechanical Engineers have learned with sincere sorrow of the passing away of George Westinghouse, Past-President and Honorary Member of the Society.

His genius as an inventor, designer and constructor has aided in making the Profession of Engineering in America known and respected the world around.

His air-brake invention was epoch-making in the field of transportation and changed the history of civilization.

His indomitable courage and perseverance have caused vast industrial works of national importance to exist.

His sterling uprightness in affairs has commanded the respect of all men.

His great-hearted manliness and purity of life have won the love of many friends."

CALVIN W. RICE, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are under twenty-five years of age and therefore qualified for Junior grade only. The Membership Committee and in turn the Council urge the members to assume their share of the responsibility of receiving these candidates into the membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before May 11, 1914.

[1] Contributed to the Iron Trade Review.

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ACKERMAN, J. WALTER, Ch. Engr. & Supt., Auburn Water Wks., Auburn, N. Y.

ADAMS, WILLIAM C., Engr., Chase Metal Wks., Waterbury, Conn.

ALBERTSON, DAN J., Civ. & Industrial Engr., and Mill Arch., Kalamazoo, Mich.

ALLEN, RAYMOND C., Civ. & Cons. Engr., and Engr. for town of Manchester, Mass.

ANDERSON, CHARLES H., Supt., Pumping Dept., Cincinnati Water Wks., Cincinnati, Ohio.

ANNETT, EDWARD B., Asst. Engr., Bd. of Pub. Utility Commissioners for State of New Jersey, Newark, N. J.

ATKINSON, ALBERT W., Asst. Secy., Victor Talking Mch. Co., Camden, N. J.

AUEL, CARL B., Dir. of Standards, Processes & Materials, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

BACKER, ELMER F., Charge of new designs and experimental work, Davenport Locomotive Wks., Philadelphia, Pa.

BANCROFT, JOSEPH, Treas., Joseph Bancroft & Sons Co., Wilmington, Del.

BANKWITZ, FREDERICK E., Asst. Managing Engr., Fletcher-Thompson, Inc., Bridgeport, Conn.

BARNES, JOHN A., Inspr., Locomotive Superheater Co., New York.

BATES, GEORGE H., Secy. & Treas., Staten Island Shipbuilding Co., Staten Island, N. Y.

BAUMES, PALMER B., Dist. Mgr., Ball Eng. Co., St. Louis, Mo.

BAYARD, ROBERT A., Asst. to Supt., Norton Co., Chippewa, Ont.

BEAVER, CHARLES W., Mgr., Hoist Dept., The Yale & Towne Mfg. Co., New York.

BECKER, ADOLF J., Vice-Pres., Becker Steel Co. of America, New York.

BEDFORD, RUSSELL B., Pres., Railway Materials Export Corp., New York.

BEESON, ALPHONZO C., Vice-Pres. & Genl. Mgr., Indiana Pipe Line Co., Huntington, Ind.

BELCHER, WARREN J., Supt., Whitney Mfg. Co., Hartford, Conn.

BELL, JESSE M., Mech. Engr., Lockport, N. Y.

Bellamy, Leon, Rep. & Designer, Dodge Mfg. Co., New York.

Berg, John D., Vice-Pres., Bravo Doyle Co., Pittsburgh, Pa.

Berman, Louis K., Mgr., Raisler Heating Co., New York.

Bernhard, John H., Vice-Pres., Alabama & New Orleans Transportation Co., New Orleans, La.

Biebler, Conrad A., Sales Engr., Hyatt Roller Bearing Co. and T. B. Woods Sons Co., Milwaukee, Wis.

Bird, James P., Treas., Watson-Stillman Co., New York.

Black, Charles A., Supt. of Dredging, Isthmian Canal Com., Cristobal, C. Z.

Blakeman, John W., Acting M. M., Bridgeport Brass Co., Bridgeport, Conn.

Bonine, Charles E., Cons. Engr., 609 Harrison Bldg., Philadelphia, Pa.

Bosler, Benjamin E., Asst. Supt. of Mech. Dept., Shops, Cambria Steel Co., Johnstown, Pa.

Bossinger, Ernest L., Asst. to Ch. Engr., The Midvale Steel Co., Philadelphia, Pa.

Bramhall, Charles T., Ch. Engr., The Exeter Machine Wks., New York.

Brazier, Frederick W., Supt. of Rolling Stock, N. Y. C. & H. R. R. Co., New York.

Broom, Benj. A., Designing & Supervising Engr., Sioux City, Iowa.

Brown, Alfred C., Genl. Supv. of Equipment, Edison Div., Lamp Wks., General Electric Co., Harrison, N. J.

Brown, Lyman H., Mech. Engr., The Travelers Ins. Co., Hartford, Conn.

Browning, Frank H., Mech. Engr., Union Sulphur Co., Sulphur Mines, La.

Bruce, Alfred W., Charge of Specification Dept., American Locomotive Co., New York.

Bruff, C. L., Combustion Engr., United Gas Improvement Co., Philadelphia, Pa.

Buck, Carl F., Mech. Engr., American Smelting & Refining Co., New York.

Burdick, George S., Estimating Engr. & Rep., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Burges, Charles W., Supt., Yost Typewriter Wks., Bridgeport, Conn.

Burleigh, Robert B., Asst. Foreman, Baldwin Locomotive Wks., Eddystone, Pa.

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Hanshew, George O., Charge of Engrg., J. D. Maxwell Motor Corp., Tarrytown, N. Y.

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Topping, Howell, Engr. & Rep., Ohio Locomotive Crane Co., New York.

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ZWOYER, ELLSWORTH B. A., Designing and Erecting Briquette Machinery and Briquetting Plant, Zwoyer Fuel Co., New York.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ASRIEL, CAMILLO J., Draftsman, Ingersoll-Rand Co., Phillipsburg, N. J.

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BLACKBURN, BYRAN M., Asst. Engr., R. D. Cole Mfg. Co., Newnan, Ga.

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BRENGEL, FREDERICK J. J., Head, Production Dept., Safety Car Htg. & Ltg. Co., Jersey City, N. J.

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Graesser, Carl F., Draftsman, New York Steam Co., New York.

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Henry, Vernor S., Asst. Engr., Safety Car Htg. & Ltg. Co., Jersey City, N. J.

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Keasbey, Aertsen P., Asst. to Pres., Robert A. Keasbey Co., New York.

Lesher, Paul T., Checker, Engrg. Dept., New Jersey Zinc Co., Palmerton, Pa.

Mattson, Earl N., Draftsman & Designer with E. B. Van Keuren, Birmingham, Ala.

Neilan, Robert H., Asst. in Mech. Engrg., Ohio State Univ., Columbus, Ohio.

Rutter, John A., Tasksetter, Gantt Bonus System, Standard Roller Bearing Co., Philadelphia, Pa.

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Smith, Miles M., Asst. Mech. Engr., Hartwell Iron Works, Houston, Texas.

Taylor, Wm. H., Instr., Penn. State College, State College, Pa.

Voelker, Frank, Asst. to Engr. of Tests, New York Edison Co., New York.

Wiedemann, Frank R., Draftsman, Weber Electric Co., Schenectady, N. Y.

Woodman, Joseph C., Supt. of Constr., Decarie Incinerator Co., Minneapolis, Minn.

TRANSFER FROM ASSOCIATE

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PROMOTION FROM JUNIOR

Austin, Adolph O., Refrigerating Engr., Karl Wegeman Co., New York.

Autenrieth, George C., Instr., College of City of New York, and Engr., G. C. Vaporizer Co., New York.

Baxter, Burke M., Associate, H. B. Prather, Cons. Engr., Cleveland, Ohio.

Bowerman, Myron R., Instr., Kansas State Agri. College, Manhattan, Kansas.

Campbell, Gordon, Pres. & Genl. Mgr., York Railways Co., York, Pa.

Cunningham, George H., Designer, Anaconda Copper Mining Co., Anaconda, Mont.

Danforth, N. Loring, Pres., John W. Danforth Co., Genl. Contrs., Buffalo, N. Y.

Goentner, Wm. B., Asst. Engr., Dept. of Water Supply, Gas & Elec., New York.

Hargrave, Russell W., Cons. Engr., also Principal of Industrial Continuation Schools, City of Menasha, Wis.

Howard, Cecil D., Designing Engr., Gas Engine Dept., National Transit Co. Shops., Oil City, Pa.

Hvid, Marinus, Ch. Draftsman, Inland Steel Co., Indiana Harbor, Ind.

Johnson, Wm. M., Engr., Charge of Water Supply & Fire Protection, Panama Pacific Internatl. Exposition, San Francisco, Cal.

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Kennedy, Wm. A., Testing Engr., Genl. Fire Extinguisher Co., Providence, R. I.

Klein, Wm. H., Supt., Dixie Portland Cement Co., Richard City, Tenn.

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Midgley, Frederick W., Ch. Draftsman, Otis Elevator Co., New York.

Morehead, Wm. C., First Vice-Pres., National Light & Power Co., St. Louis, Mo.

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Seward, Herbert L., Instr., Sheffield Scientific School, New Haven, Conn.

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Thoma, Charles, Supt., Die Dept., E. W. Bliss Co., Brooklyn, N. Y.

Thoma, Walter, Ch. Mech. Inspr., E. W. Bliss Co., Brooklyn, N. Y.

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Williams, Fay B., Mech. Engr., Lamson Co., Boston, Mass.

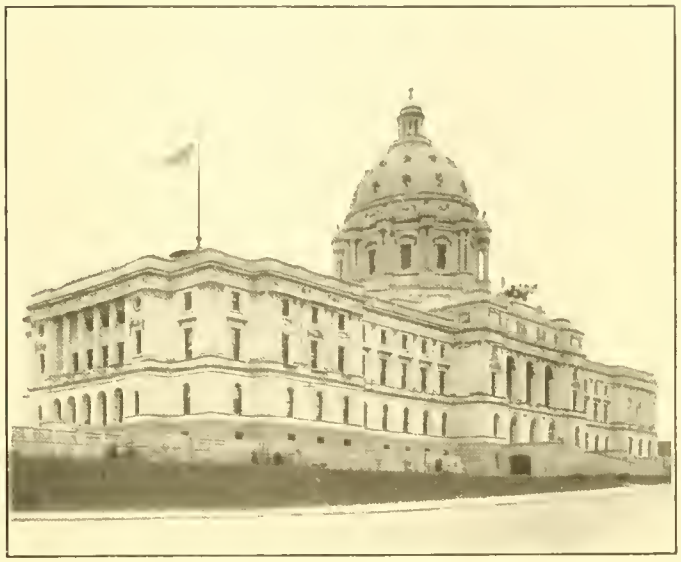
SUMMARY

New applications	300
Transfer from Associate	1
Promotion from Junior	28
Total	329

THE ST. PAUL—MINNEAPOLIS MEETING

FEATURES OF THE TWIN CITIES WHERE THE SPRING MEETING IS TO BE HELD

THE Twin Cities, located at the geographical center of North America, have become the great commercial center of the American Northwest; with distinct business sections but ten miles apart, they merge in a large manufacturing district. Four interurban street car lines connect them, furnishing fast and convenient service with large and easy riding cars.



Minnesota State Capitol

The location of these cities has made them a center for nine railroad systems, the passenger and freight traffic of which are enormous. A government dam, already in process of construction between St. Paul and Minneapolis, will open the Mississippi River as another important avenue of transportation. Boats, which now come up the river only as far as St. Paul, will, at the completion of this dam, be able to reach Minneapolis.

St. Paul, though it is a manufacturing and jobbing city of reputation and a great railroad terminal, is most important as the capital city of the North Star State. It is built on a series of hills that rise gradually from the banks of the Mississippi, and every advantage has been taken of the natural beauties to make the city picturesque. The main business portion lies on a great plateau just above the river's edge; beyond in every direction rise hills on which rest the residence sections of the city.

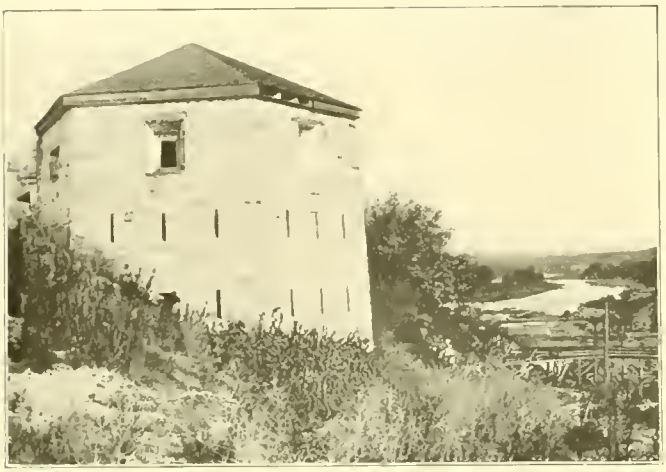
Scores of beautiful parks dot the city over, the chief being Como Park, with an area of 425 acres, in the midst of which are two fine little lakes, and Phalen

View of Mississippi River and Public Baths, St. Paul

Park, containing 469 acres. On an island in the river opposite the main business section of the city are the free public baths, with public playgrounds and a zoo. On other islands in the river are headquarters of the rowing, motor boat and canoe clubs. Just above the islands is the famous High Bridge, a structure spanning the river, with a roadway 2717 feet long and 224 feet above the river.

Summit Avenue has for years held its place as one of the most beautiful residence avenues in the country. For a long distance the avenue skirts the bluff, affording a splendid view of the river below, the opposite bluffs, and the business portion of the city. Several miles out, Summit Avenue joins the River Drive, which runs along the bluff from Fort Snelling to Minneapolis. But a few miles beyond the fort are the Falls of Minnehaha, made famous by Longfellow.

Panoramic View of St. Paul Taken

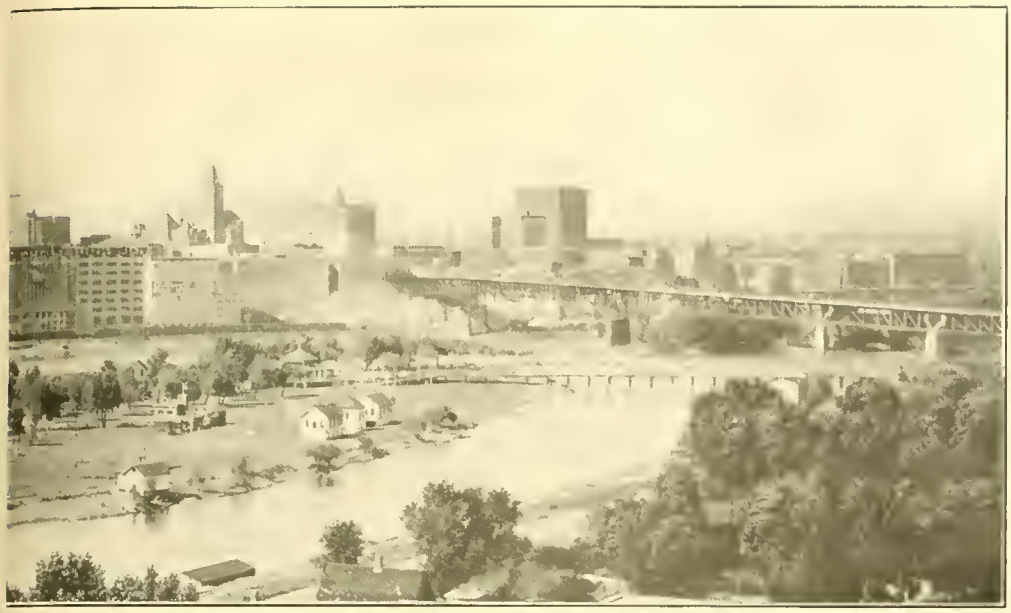


Old Stone Tower at Fort Snelling, Minneapolis

St. Paul's public buildings are many and interesting, some of the finest being the Minnesota State Capitol, the new Roman Catholic Cathedral, the municipal auditorium, and the James J. Hill Reference Library, now in course of construction.

Minneapolis, granting to St. Paul the political precedence, claims for itself the title of commercial capital of the State of Minnesota. It is essentially a manufacturing city, and ranks fourteenth of all the cities of the country in volume of manufactures, while at the same time it is recognized as one of the most beautiful

Panoramic View of Minneapolis Looking East from Hotel Leamington



FROM WEST BANK OF MISSISSIPPI RIVER

Copyrighted by C. B. Gibson, St. Paul

belonging to Mr. T. B. Walker, which is one of the best in the country. The Civic and Commerce Association of the city has a membership of 3000, and in two years has attained prominence as one of the most effective organizations of its kind in the United States.

Twenty lakes are to be found within the city limits of Minneapolis, and nearly as many more in St. Paul; fully one hundred others are within a radius of 25 miles of each city. White Bear Lake is reached by fast electric cars from St. Paul. This is a beautiful body of water with irregular shore lines dotted with fine summer homes. A few minutes' ride beyond

cities in the world. The city as a manufacturing center owes its existence to the Falls of St. Anthony in the Mississippi. The early reduction of the forests and the beginnings of wheat growing in the Northwest made the saw mills and flour mills the first industries, but others came, and today there are 1200 manufactories. Minneapolis is the world's chief producer of flour, with immense mills and two of the largest grain elevators in the world.

Minneapolis is the seat of the state university, the campus of which covers 85 acres on the east bank of the river, and the enrollment of students this year in the eight colleges and three schools is nearly 7000. The city is an art center and a magnificent museum is being erected in the residential district. There are many private collections of paintings, among them that

MR. GEBHARD BOHN'S RESIDENCE, LAKE MINNETONKA

Copyrighted by C. J. Hibbard, Minneapolis

MILLING DISTRICT ON EXTREME RIGHT IN THE BACKGROUND

Scene on Lake Harriet, One of the Attractive Pleasure Resorts in Minneapolis

White Bear village lies Bald Eagle Lake, another summer resort. Lake Gervais, several miles distant, is connected with Phalen Park within the city itself, by a Venetian waterway. Nearly all of the city lakes in Minneapolis are controlled by the park board and held by it for the benefit of the people. Over 3700 acres, or one-ninth of the entire area of the city, is in the park system. Four of these lakes, none of which is more than four miles from the downtown district, are connected by lagoons. Cedar Lake, Lake of the Isles, Lakes Calhoun and Harriet, are all within 15 or 20 minutes' ride from the center of the city, and offer bathing, fishing, boating, music and refreshments. At Lake Calhoun is the beautiful Calhoun Bath House and the finest inland bathing beach in America. Lake Minnetonka, 20 miles distant, with its beautiful islands, bays and wooded heights, with its more than 100 miles of irregular shore line, is one of the most picturesque lakes in America. Some 15,000 to 20,000 from the Twin Cities have summer homes around the lake, many of which are magnificent residences. It can be easily reached by trolley or by one of two railroads. Mr. Gebhard Bohn of St. Paul will entertain the Society and its guests at his home on Crystal Bay, Lake Minnetonka.

View of Summit Avenue, St. Paul, One of the Fine Residence Streets of the Country

EFFICIENCY OF ROPE DRIVING AS A MEANS OF POWER TRANSMISSION

BY E. H. AHARA, MISHAWAKA, IND.

Member of the Society

THIS paper deals with a series of tests on transmission of power by rope drives under various conditions. The efficiency is measured under full, three-quarters, one-half and one-quarter loads. One inch best manila rope was used. The test covers drives of from one to eight ropes, with centers from 25 to 150 ft., on both American and English systems. Tests also covered open or straight drives, as well as indirect, or up and over drives.

It was stated that the importance of the tests may be estimated from the conclusions deducible from the data obtained. They seem to show that the efficiency in rope driving is considerably greater at the lower speeds than at the higher ones, the dropping off being especially noticeable above 4500 ft. per min. of rope speed. They also show that the efficiency of a rope drive is not materially affected by distances between centers up to 150 ft., that the drop of efficiency at 50 per cent load is comparatively small over that of full load, and that if proper care is exercised to have all grooves perfect in pitch diameter many as well as few ropes can be run on a drive with good efficiency. With the American system, increasing the slack rope tension up to 360 lb. in a 1-in. rope does not appear to decrease its efficiency, but rather to increase it if power is used in conformity with this tension; but only such tension should be used as is necessary to drive the load needed. For the rope tested the American system has very much more capacity than the English system, and has also a higher percentage of efficiency. In general it would appear that, where there is a considerable power to be transmitted, the properly worked out rope drive gives a most efficient and economical method, and where conditions are favorable to its installation no other known method of transmission will so well conserve power losses.

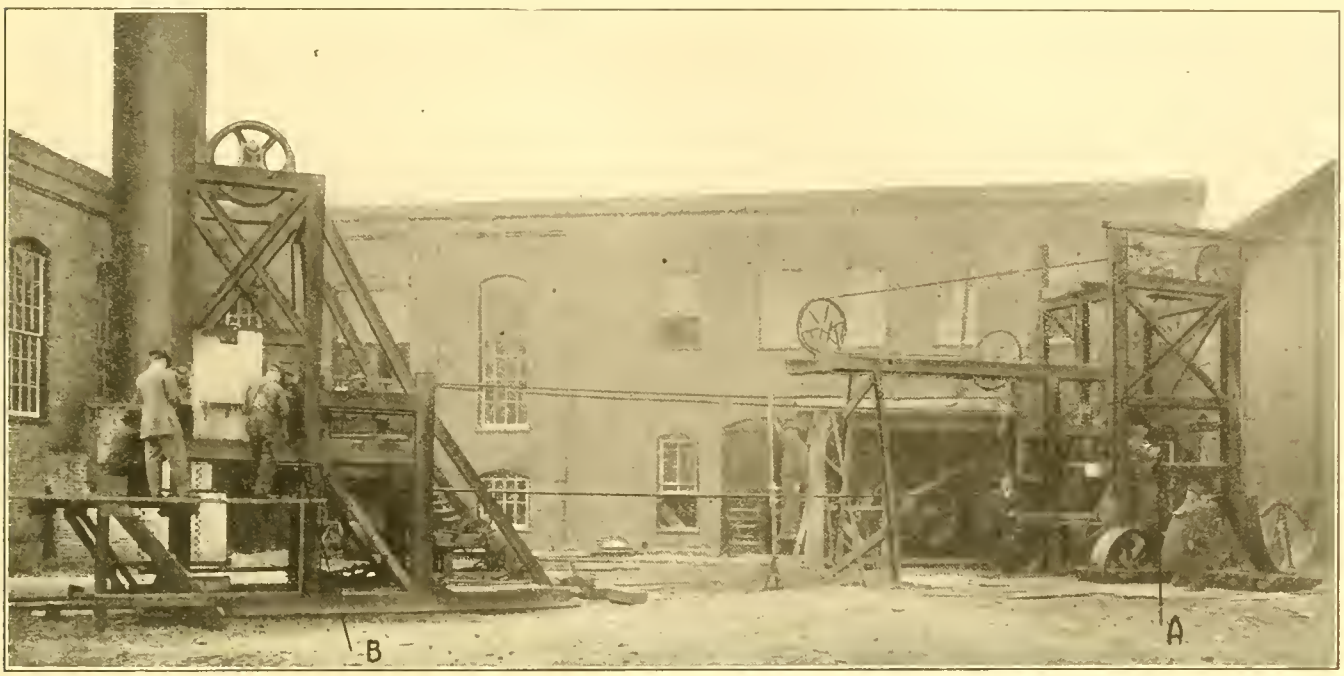


FIG. 1 ARRANGEMENT OF APPARATUS FOR TESTING ROPE DRIVES, SHOWING AN AMERICAN OPEN DRIVE, 50 FT. ON CENTERS, SEVEN ROPES, 4500 FT. PER MIN., 155 H.P.

The efficiency as determined includes the losses in the rope itself, the friction in the bearings on the driven shaft, and the losses due to the inertia of the driven wheel and the prony-brake wheel, and, also, in the American system the friction of the tension equipment. All tests were made to include the friction of the receiving shaft and bearings as it was thought this would more nearly approximate working conditions and make the data obtained of more general application in ordinary comparisons. All bearings used were of the ring oiling babbitted type, and the ropes were all 1-in. ma-

Abstract of Paper. Published in complete form in the August 1913 issue of The Journal of The American Society of Mechanical Engineers, and presented at the Annual Meeting, December 1913. Pamphlet copies may be obtained: price, 10 cents to members and 20 cents to non-members.

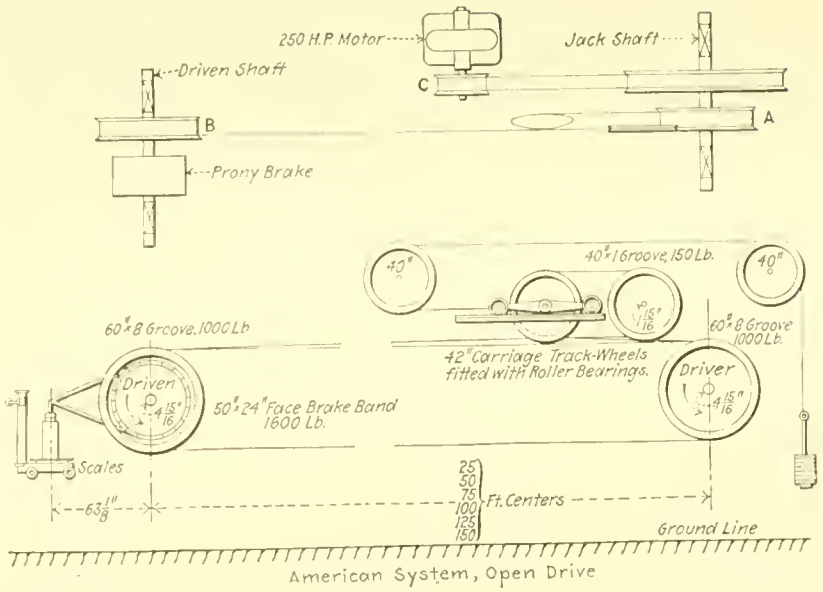


Fig. 2 General Plan of American Open, or Straight, Drive System

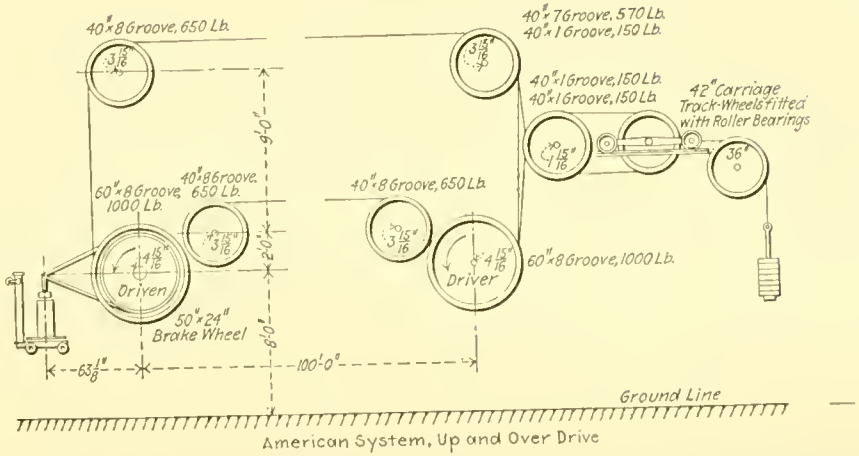


Fig. 3 General Plan of American "Up and Over," or Indirect, Drive System

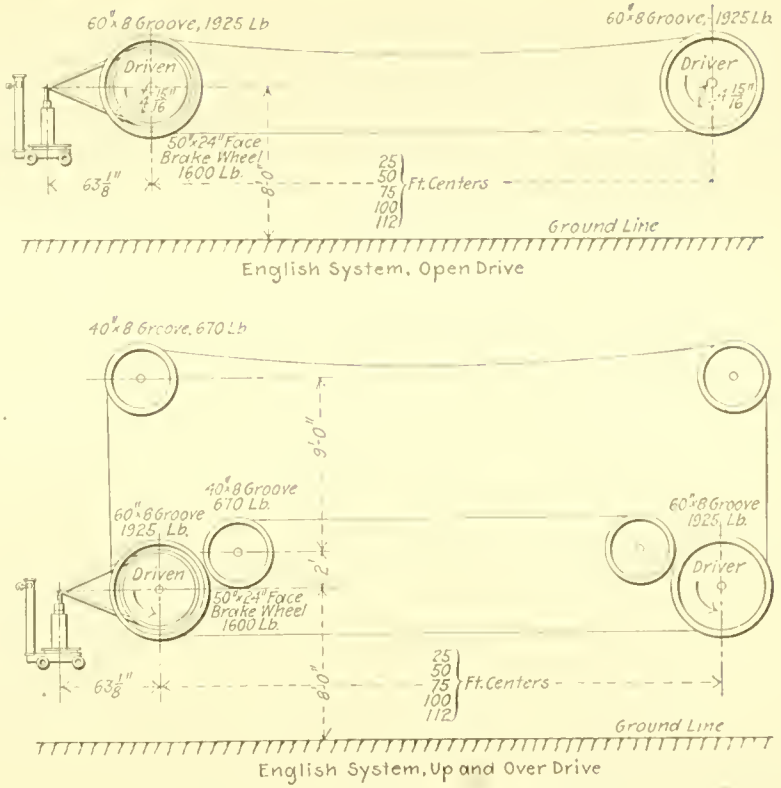


Fig. 4 Plan of English Open Drive and "Up and Over" Drive Systems

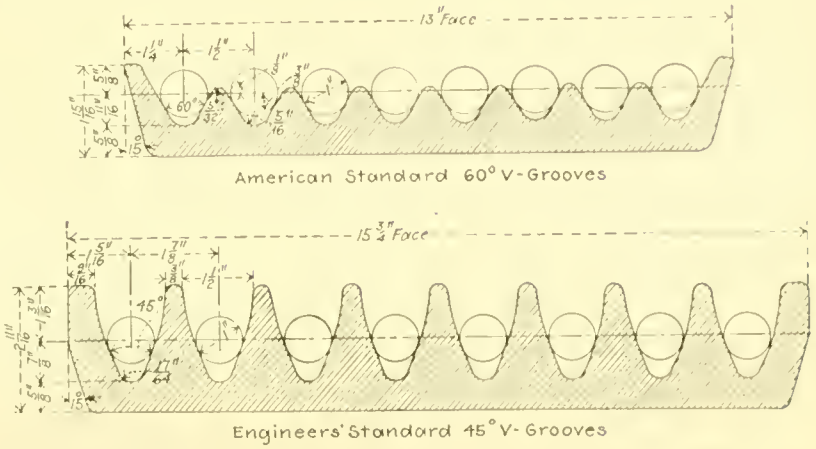


Fig. 5 Details of Grooves used on Driver and Driven Wheels

nila rope of best quality, carefully treated with a rope dressing to prevent the entrance of moisture and to keep the surface in as nearly uniform condition as possible. It was found during the test that this was of great importance as very slight changes in the rope surface immediately affected its capacity and efficiency.

With the American system a lower efficiency is shown on the lower number of ropes. This is undoubtedly caused by the fact that the eight-grooved wheel made for testing eight ropes was used for all the lesser number of ropes to avoid the expense of making additional wheels with a suitable number of grooves for each drive. This together with the weight of the prony brake increased the proportional friction on the smaller loads, and is, therefore, a larger percentage of the total load in the drive of few ropes. With the friction of driven shaft eliminated, limiting the losses to those in the rope alone, it is believed the efficiency in a single rope would be as great if not greater than any multiple thereof.

In all of the above tests the tension in the slack side of the rope was kept as uniform as possible at 180 lb. by means of weighting the tension carriage properly. In order to ascertain what tension would give the greatest degree of efficiency, irrespective of life of rope or wearing qualities, a test was made with the slack rope under varying tensions. This is determined on one rope because the capacity of the single rope was, under the heavy tension, as great as that of the motor, so no proper comparison could be obtained on more than one rope.

One of the greatest troubles in rope driving, when installed by inexperienced engineers, has been the lack of uniformity in pitch of the grooves where many ropes were used. This differential in the grooves compels slippage of the ropes which not only causes loss of power, but also rapidly depreciates the rope, and often causes the rope to flop around badly. To test the loss of efficiency in this case two wheels 60 in. in diameter, of eight grooves each, were made up exactly alike so far as could be, and after most careful measurements the grooves on either wheel were found not to differ more than 1/64 in. in circumference from any other on the same sheave, and a test made. The driver was then removed, and the pitch diameter of each groove made approximately 1/32 in. less than the preceding groove so the eighth groove was ¼ in. less in diameter than the first one. Again it was placed on the driving shaft and a duplicate set of tests made. In this test as the first groove was ¼ in. larger in pitch diameter than the eighth groove, with the sheave revolving at 160 r.p.m., there would necessarily be a slippage in an inelastic band of over ten feet per minute. The photographs taken of this differential drive, shown in the August 1913 issue, are quite illuminating, as they show plainly the sag of the various ropes under this condition, and how under heavy load they stretch and slip on the grooves of the sheave. The elasticity of the rope in this case undoubtedly lends itself to aid efficient operation.

The "up and over" American drive was tested because it is typical of all but direct drives, i. e., straight from driver to driven, and the difference in efficiency between this type and the open drive will serve as a basis of comparison where but two additional right-angle turns are introduced requiring four additional idlers. This test was run on approximately 100 ft. centers with a new rope, the same rope being afterwards used in the testing of the various English drives.

In testing the English drives, that proper comparisons might be made, the ropes were all cut to the same measured length, and the splices carefully made, so that all ropes might be equally tight when applied to the sheaves. The movable tower was then carefully moved back, the rope being run slowly meanwhile until the sag in the rope was approximately the same as in the American drive of the same center distance in which the slack rope was under a tension of 180 lb. This is undoubtedly a higher tension than is used in general practice on the English drive system with this size of rope, and the capacities and efficiencies shown are perhaps higher than are ordinarily attained in common practice. The efficiencies, when compared by speeds, of the English open drive, show a marked decrease as the speed of the rope increases, falling as low as 84.5 per cent at 5500 ft. rope speed.

The general tendency in all tests made, both English and American, was corroborative of this tendency toward decrease in efficiency as the speed of the rope increases. There was, however, a lack of smoothness to many of the curves owing, it was thought, to variations in rope tension, and perhaps slight changes in the surface of the rope due to climatic changes. This was very much more noticeable on the English than on the American system, the irregularity of the curve on the former being affected by the fact that a greater load was sometimes attained on a certain speed than could later be reached on the next higher speed.

The efficiency of the English drive, within the limit of distances tested, remains practically constant irrespective of center distance; while with reference to number of ropes, it increases as does the American for the first few ropes, and then remains practically constant through the additional ones.

In order to test the effect of tension on the English system a comparison was made by moving the receiving tower forward 1¼ ft. after making a series of tests, and then making another corresponding series. When sheaves with proper English pinch grooves, as shown in Fig. 5, were used there was no appreciable difference either in power transmitted or in efficiency. Greater variations than 1¼ ft. in center distances could not be satisfactorily tried because of the slack ropes dragging on the ground.

A new rope was used on the American open drive, another new one being started with the American "up and over," which latter was also used on both the English drives. The time of introducing the new rope is mentioned because it was found that a new rope had very much less capacity, owing to its low coefficient of friction, than the same one had after it had run a short time in work, and having less capacity it would usually have less efficiency also. The stiffness of the rope when it was new also seemed to add friction to the drive owing to the bending action in passing around the sheaves, which on the test were only 60 in. in diameter. With larger main drive wheels, where the rope is not bent to so small a radius, the efficiency would undoubtedly be slightly increased over the results here shown.

The capacities of rope drives are affected by so many variables that no particular attempt is here made to state capacity other than in general figures, obtained as indicated in the early part of this paper, and used merely to have a uniform method of taking the tests. In the original paper in the August 1913 issue some limiting capacities obtained in the open drives, and in the "up and over" drives, are presented in curves. These limiting capacities shown are in no sense to be considered as available working capacities, but merely as limits reached in driving capacities, the general tendency of the whole series being used to form a decision, rather than any one curve, the practical working capacity being much lower than the limits shown. It is to be regretted that the power available was not great enough to get the larger capacities as so few points were obtainable on the American open system. Even at the low speed of 2500 ft. four ropes could not be made to slip with the 250 h.p. available.

The irregularities of these limiting horsepower capacities are caused by many variables, some of which are weather, surface conditions of rope, condition of rope wheel grooves, etc. In connection with the groove in the wheel it was found that if a rope began to slip in a groove and warmed it up slightly the coefficient of friction seemed to decrease very rapidly, and if a limiting test were made under these conditions it was invariably much lower than if it were taken just before the rope started to slip. As each test had to be taken in its scheduled order some of those shown were taken at intervals of several weeks.

As the limiting capacities of the English drive are very much lower than the American, it is thought the efficiency is likewise affected, the friction in the former case being a much larger proportion of the power delivered. And again, the English system in order to get driving power in the rope, pinches it in the narrow groove requiring considerable force to withdraw it again. This effort being exerted continuously uses up considerable power. The American system, on the contrary, uses a 60-deg. groove in which the rope lies freely and withdraws without effort.

DISCUSSION

Henry G. Stott said that the question of efficiency was, of course, a very important one, but there was also another involved, the question of reliability. He had had a good deal of experience in driving high-speed machines with rope drive on the European side of the Atlantic, where both systems were used. While the American system of continuous rope was a good deal easier to operate, yet in the case of an accident to the rope, the entire rope became tangled up and something else was broken; whereas with the English system of separate drives, there was a number of ropes, each one separate, and if one rope broke the work was not interrupted, so that the question of reliability should also be taken into consideration.

Geo. N. Van Derhoef (written). Why does the efficiency decrease as the speed increases, in both the American and English systems? In the American system the slack side tension at any speed is equal to one-half the pull of the carriage plus the centrifugal force due to the speed; while the slack side tension in the English system is due to the initial tension less the centrifugal tension, and less a decrease in tension due to the total elongation of the rope band due to its elasticity. Is this due to "skin friction" of the rope sliding through the air, or to bending and unbending of the rope (either or both of which would indicate a functional loss due to speed), or on the other hand, is it caused by a change in the coefficient of friction of the bearings, which would indicate that the loss was entirely outside of the rope and that a high-speed rope may be as efficient as a low-speed one. This is quite an important point because in the design of many large drives the speed or travel of the rope can be made almost anything desired.

The tests showing the results for different distances between centers would seem to eliminate the "skin friction" idea, because the difference in the total length of rope is sufficiently marked to make any loss of this kind of any amount quite perceptible. In the English system test, the slight downward tendency to the average line is not sufficiently marked from which to draw any conclusion.

The tests showing that with the American system the efficiency at half load is practically the same as at full load, indicates that a drive may be designed to take care of occasional peak loads without a sacrifice in efficiency when operating at the average normal load we usually get in practice; or, to put it another way, without loss in efficiency when meeting a peak load, which, although generally of momentary duration, may at times be prolonged over considerable periods. If this is functionally true of American system rope drives in general, it is a most important characteristic.

The tests covering the efficiency with different numbers of ropes with drives of both systems show two important things: (*a*) that it is of basic importance that the sheaves be accurately grooved; and (*b*) that with properly grooved sheaves, drives for large powers, where many wraps of rope must be used, will not apparently be accompanied with any loss in efficiency. This seems to be quite different from what we find with large belt drives where the crowning of the pulleys gives an inherent loss that cannot be entirely prevented. A corollary from the above is that the choice between a few ropes of large diameter and a good many ropes of small diameter is not dependent upon the question of efficiency but on other design factors.

The fact that increasing the slack side tension up to at least 360 lb. for a 1-in. rope increases rather than decreases the efficiency is important to both the designer and user. No doubt the life of a transmission rope depends very largely on the load factor. Still, it is often necessary to increase materially the load on any transmission due to changes in operation, emergency, etc., far beyond that contemplated in the design. That this can be done with the American system simply by increasing the tension weight and at no greater penalty than a more or less proportionate decrease in the life of the rope means great flexibility and certainty in getting out production.

That the efficiency of the so-called up and over drive is less than the direct is only what might be expected from the greater number of parts. That this seems to be rather less marked in the American than the English system is in line with the results shown by all the various tests.

That the coefficient of friction of a new rope is less than that of a conditioned one is well known. In the design of an English system drive great care must be exercised to have the drive amply large to transmit the power desired when the rope is new, otherwise full operation cannot be secured until the ropes have been conditioned. In designing the American system it is not necessary to give any attention to the coefficient of friction of a new rope at all. The design should be based on the actual normal running condition. All that is necessary to do when a new rope is put on the drive is to use the proper amount of tension weight to give the desired traction and to reduce same just as rapidly as the rope becomes conditioned and the coefficient of friction rises to the normal point.

To secure all the advantages that are possible with the American system drive the driving and driven shafts should be of ample size so that extra tension weight can be used whenever desired, otherwise the great flexibility of this system would be unavailable on account of a detail that should have attention at the time of designing.

W. H. Kenerson asked whether the result, outlined in one of the curves, showing that the efficiency dropped with increase in speed, was derived from the four individual observations, or whether the points were the average of a large number. If, as the author further showed in another curve, the distance between centers did not affect the efficiency, or in other words, the line drawn through those five points was a straight line horizontally, it would be seen that if those were individual results only, it could be just as fairly deduced from the first curve that the line was horizontal; in other words, the variations due to other causes, possibly, would be as much as 4 per cent, as indicated.

Selby Haar (written). Having had occasion to estimate the losses of power in rope transmission, I can cordially endorse Mr. Ahara's opening statement. It is difficult enough to find reports of actual tests relating to the efficiency of belt drives, but there is even less in print about efficiencies of rope drive. It was in the course of a search for such data that some investigations were discovered which form the basis of a paper[1] presented at the December meeting of the Society in 1910. These tests included a large number on rope transmission for which the efficiency was carefully determined.

The description of the testing machine of that paper may be summarized here in the statement that the machine is horizontal, very compact because both driving and driven shafts are located in the measuring and straining heads respectively, and electric motors for supplying and absorbing energy are mounted directly on the shafts. The sheaves were specially designed for these tests, had diameters 2500 mm. (98.5 in.), 1500 mm. (59 in.) and 1040 mm. (41 in.), with 45 deg. V-grooves. Pains were taken to have all grooves nearly the same diameter. Most of the tests were conducted on a round manila three-strand rope 50 mm. (2 in.) diameter, 20.5 m. (67 ft.) long, the rest being taken with six-strand, so-called trapezoidal rope, with a sectional area approximately equal to that of the round rope. The majority of observations was made on transmission on the English system; the arrangement with endless rope was probably not entirely representative of the American system, the automatic adjustment of the tension in the rope being lacking.

The readings for a test included volts and amperes for power both supplied and delivered, rope-speed, rope-pull and revolutions. In order to determine the efficiency, however, only the electrical readings are required. All electrical, bearing friction, and windage losses of the testing machine were determined and allowed for so that the efficiencies reported apply to the rope only.

Upon this basis the English system showed higher efficiency than the American. All test results are reported in the form of curve-sheets, the efficiency curves of single tests being superposed, and, so to speak, enveloping curves constructed from them, from which the upper and lower limiting efficiencies at any given load or speed may be taken. On the English system with a 2-in. round rope, the highest efficiency reported is 0.89 to 0.945 at 38 kg. (84 lb.) effective pull per rope for four ropes, and 0.945 to 0.97 at 100 kg. (220 lb.) for a single rope. Pulleys of like diameters were used, while the distance between centers was about 6 m. (20 ft.). The tight part of the ropes was on the bottom. It was also observed that the use of driving sheaves smaller than the driven ones did not affect the efficiency, but when the larger sheave drove, the efficiency was reduced. Furthermore, the efficiency decreases with increasing speed, one set of values being 0.95 at 13 m. per sec. (2550 ft. per min.), 0.925 at 30 m. per sec. (5900 ft. per min.) and 0.90 at 39 m. per sec. (7700 ft. per min.). With an endless rope (American system) maximum efficiencies as follows were reported: 0.86 to 0.895 at 55 kg. (121 lb.) effective pull per rope. A particular value with three wraps of rope on pulleys 5933 mm. (19.5 ft.) apart, 1040 mm. (41 in.) (driver) and 2500 mm. (98.5 in.) (driven) at a rope speed of 26 m. per sec. (5100 ft. per min.) is a maximum efficiency of 0.89 at the effective pull 50 kg. (110 lb.) per rope. Practically equal values were obtained (also equal carrying capacities) whether the tight part of the rope was on top or bottom. The initial rope tension was also reported, the most favorable value for the 2-in. rope from the standpoint of efficiency and smooth running being about 150 kg. (330 lb.). Other interesting observations are the recommendation of a maximum rope speed of approximately 25 m. per sec. (5000 ft. per min.) and the confirmation of the prevalent

[1] A New Theory of Belt Driving, The Journal, Am. Soc. M. E., December, 1910.

opinion that with constant initial tension and rope speed the efficiency increases with the sheave diameter.

Although no figures relating to the trapezoidal rope are given, it is reported that its efficiency is lower than that of the round rope.

The formulae for calculation of efficiency developed in the previous paper were applied to several of the observations reported in the paper, but with a disappointing result, because in all cases the observed losses were much greater than calculation, not taking into account windage losses of the driven sheave and brake pulley, indicated.

The Author. Answering Mr. Stott's question as to reliability, there is very little liability of accident from rope drives if properly installed, and given even a fraction of the attention that other means of transmission require.

It is common practice by those most experienced in the installation of rope drives to safeguard them by placing what is called a tell-tale, an electrical device, below the rope where a bend is made around the sheave that will, in case the rope becomes stranded at all, make an electrical connection and either throw out a clutch stopping the drive entirely or ring a gong to notify the engineer so the rope may have immediate attention.

If a rope is properly inspected occasionally, should any distress appear, it will be observed and then can be repaired at night and never occasion any delay during working hours.

With either English or American methods the freedom from delays depends on the care in inspecting. There is but one rope to watch in the American system while there are many in the English. It is a common occurrence for American drives to run three or four years without touching the rope at all when properly installed.

Mr. Van Derhoef raises a hard question: Why is a rope more efficient at low than at high speeds? My tests have not gone far enough to determine these causes. All the tests made, however, covering this long period of time, indicated in every case that the higher the speed the lower was the efficiency. It would take a long series of tests to develop why this is, but there is no doubt of the fact.

If Mr. Kenerson will refer to the various curves presented in the paper, he will see the same general results as he refers to so far as the decrease of efficiency as the speed increases. This was a general fact shown by a great many tests, and is not depending on an isolated test (tests were not made below 2500 ft. rope travel per minute).

The higher efficiency at low speeds is probably not due entirely to one cause. Skin friction and rope elasticity are possibly factors. The power to drive the sheaves and bend the rope at the high speeds may be more, proportionately, than at the slower speeds.

In Mr. Haar's discussion there are several tests reported that would not be considered good practice in rope transmission work, and therefore have little actual bearing on the subject.

A 2-in. rope would not be effective on pulls of 84 lb. or even 220 lb. This would be especially true in the American system where 180 lb. in the slack side for a 1-in. rope is a common tension. The so-called American system without automatic tension adjustment is only a modification of the English system and would undoubtedly increase the friction, as it would add one sheave to the friction load without any compensating benefit. It is in no sense an American system drive, and would warrant no deductions for the American system.

It is difficult to understand why efficiencies should be lower with a large driver and a small driven sheave than with a small driver and a large driven sheave. The writer made no tests on this point, but was under the general impression there would be no difference until slipping took place, and that this would happen quicker with the small driver than vice versa.

Mr. Haar in applying his formulae to the paper perhaps did not take into account the fact that in these tests the friction of the driven end was included with the losses in the rope itself, thus making the efficiencies much lower than they would be in the rope alone, as is usually figured.

Courtesy of Tiffany & Co

Gold Medal Presented to Col. G. W. Goethals, by National Geographic Society, at Washington, D. C.
March 3, 1914

"The magic of the engineer is that he can change the face of nature and show the work of his hands, and that it is in some deep sense creative in character."—(From Presentation Speech by President Wilson.)

FIRE PROTECTION SESSION

PAPERS CONTRIBUTED AT THE ANNUAL MEETING BY THE SUB-COMMITTEE ON FIRE PROTECTION

This meeting was a symposium on Fire Protection topics, supplementing a similar session at the spring meeting in Baltimore in 1913. The papers read at the Baltimore meeting were devoted to the larger aspects of the problem as related to building construction and conflagrations; while at this meeting engineering details having a bearing on fire fighting and fire protective methods were discussed. Five papers were presented: The Fire Hazard in Turbo-Generators, G. S. Lawler, Boston, Mass.; Extinguishing of Fires in Oils and Volatile Liquids, Ed. A. Barrier, Boston, Mass.; Control of Automatic Sprinkler Valves, Fred J. Miller, New York; The Need of More Care in the Design and Construction of Elevated Tanks, W. O. Teague, Boston, Mass., and Fire Pumps, by Ezra E. Clark, Boston, Mass.

THE FIRE HAZARD IN TURBO-GENERATORS

By G. S. Lawler,[1] Boston, Mass.

Non-Member

The chances of electric generators of the older types being seriously injured by fire in the event of some part of the insulation failing is slight. Occasionally arcing will ignite the insulation at some point, but it is seldom that the fire will spread much before it is extinguished. This freedom from fire damage is due principally to the comparatively low speeds, the accessibility of the combustible insulation, and the fact that the machines being of large mass per unit capacity, the insulation is considerably distributed.

This condition of practical freedom from fire is reversed in the case of generators of the turbo type, for when a short circuit occurs in one of them there is a great chance that the insulation will be ignited and the machine be badly damaged; in fact such damage has occurred in a number of instances.

The chief causes of the increased hazard in the more modern type generators are as follows:

a The volume occupied by this type of machine is very much less for the same capacity than that of the older types of generators, so that the combustible insulation is more concentrated and, therefore, much of it is exposed, even to a slight arc or fire. The covering on the conductors depends greatly for its insulating qualities on the presence of oils or gums of a highly combustible nature. The amount of this combustible insulation on the higher voltage generators is naturally greater than in the low voltage machines.

Owing to turbo-generators having only a few poles the end connections between slots form a large proportion of the total length of conductors, in fact in some designs approximately one-half of the coils are outside of the slots. These end connections, one-half being on one side of the machine and one-half on the other, are exposed to fire, and as with a pile of loosely laid sticks, fire will rapidly extend from the insulation on one coil to that on the others.

b Owing to these generators being of exceedingly large capacity in many instances, (one of 30,000 kva. capacity now being constructed) an enormous amount of energy is involved in a short circuit, especially at the instant the short occurs and as the arc is confined in the limited space with the combustible insulation, it would seem impossible for the insulation to escape being set on fire at many points simultaneously.

c The machines are cooled by forcing large quantities of air through the spaces between the conductors. The large and constantly renewed supply of oxygen will hasten combustion when it is once started. The air is given somewhat of a rotary motion by the rapidly revolving rotor which has the ventilating vanes on it and consequently fire when started will be quickly swept around the exposed insulation.

d The generators are totally encased with the exception of the air inlets and outlets and even these in some designs are under the machines. This construction prevents access to a fire and much valuable time will necessarily be consumed before extinguishing agents can be used effectively. When the field current is cut off, as is necessary in case of short circuit, the only means of bringing the rotor quickly to rest is lost and it will continue to run for a long time after the steam has been shut off. Some machines will run for over an hour. This continued rotation is not conducive to the quick extinguishing of fire, especially when the ventilating vanes are mounted on the rotor.

In addition to the possible causes of arcing existing in the case of the older types of generators, the turbo-generator is subject to momentary large current rush at instant of short circuit, even if the short is external

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Presented at the Annual Meeting, 1913, of The American Society of Mechanical Engineers.

to the machine itself, unless means are taken to keep the current within safe limits. The heavy rush of current causes mechanical stresses in the conductors, which in some cases are severe enough to distort the conductors, especially where outside the slots, and to injure the insulating covering, resulting in a short circuit within the generator itself. In some designs the internal reactance of the machines will permit of the momentary current rush amounting to 40, or possibly more, times the normal full-load current of the machines.

The possibility of the conductors being distorted has been reduced in some cases by designing generators with sufficient internal reactance, or by providing external reactance such that the current at the moment of short circuit will not be great enough to damage the generators. Attention has also been given to supporting the stator end connections to prevent their distortion. These means have undoubtedly greatly increased the safety of the turbo-type of generator from possibilities of internal short circuit, but in no way tend to prevent a fire resulting should an arc occur.

A short circuit in the rotor will probably not result in a severe fire unless under exceptional conditions. This is also true if the short circuit occurs inside of a stator slot. A short circuit involving a stator coil, however, is more apt to occur at the end of the slot where the conductors are exposed.

As asbestos is now used largely for insulating the rotor windings and as these windings are well protected, it is probable that only in cases of severe fire in a machine will the rotor windings be damaged to any extent.

While the generators may be free from fires during the earlier portions of their life owing to the proper use of reactances which prevent external troubles seriously affecting the machines, as they get older the ordinary causes of breakdown of insulation are liable to occur and fires result. Probably in most cases generators will not be discarded until some trouble, usually in the nature of a short circuit, has occurred at least once in each, so that it is reasonable to expect that unless further preventative means are taken, turbo-generators stand a good chance of serious damage by fire at some time during their life. Although many fires have occurred, probably most of them have happened during the generator development stage. Generators of the turbo type are of such recent production that none of them has yet reached a life which could be considered old and, therefore, the troubles which can be expected near the end of their life by fire have still to come.

Undoubtedly the manufacturing companies have given serious thought to the matter of the reduction of the fire hazard in turbo-generators and have employed all means practical at the present time to this end, but there is still very much to be desired. The following several means if taken together would seem to minimize the chances of a serious fire:

a If a suitable material could be found a non-combustible outer covering could be placed over the insulation on the stator end connections. This would greatly delay the spread of fire and even if no other protective means were taken, would undoubtedly prevent much serious damage. Where fire extinguishers were used the covering would at least hold back the fire until they could be brought into play. At present no material suitable for such a covering appears to be available.

b If a non-combustible outer covering should be put on, its advantages would be partially lost in time unless the cooling air were freed of the dirt and oily vapor liable to be in it. This could be done by filtering, as has already been advocated several times.

c Means could be provided for cutting off the air supply in case of fire in generators by placing dampers in the inlet ducts designed so as to be normally held open by fusible links. The links could be placed so that they would be quickly fused by the heat and allow the dampers to close automatically. By reducing the oxygen supply to that entering by leakage the action of the fire would be slow.

d Arrangements could be provided for the quick introduction of carbon dioxide gas into the machines. The carbon dioxide could be kept in liquid form and piped through valves, expansion tanks, etc., to the generators. The valves could be arranged to be opened by the closing of the air inlet dampers so that the gas would be automatically introduced into the generators. This gas would be very effective in extinguishing fires inside the machines after the air supply had been cut off.

The employment of some efficient method of reducing the fire hazard in generators of the turbo type either along the lines mentioned or in some other way is important. The value of these generators is great and the damage by fire may amount to a considerable proportion of the first cost. It is probable that the damage is more liable to occur towards the end of the life of the generators, but even then the loss may be large, both directly and indirectly. The large central stations have reserve units so that the increased damage due to fire in one of their generators would probably not affect the continuity of service, but the increased time necessary for repairs may be long and during this time the reserve capacity will be weakened. In the case of industrial plants the longer time needed for repairs might be serious. Many manufacturing concerns who generate their own current depend on only one unit and, therefore, their whole production, or a large part of it, would be affected.

DISCUSSION

B. G. LAMME[1] (written). Having been connected with the turbo-generator business since its beginning in this country, I am naturally much interested in the conclusions drawn by Mr. Lawler. In general, his statements can be accepted, and about the only criticism which can be made is that he does not go far enough in some of his explanations and recommendations. The following may therefore be considered as a supplement rather than a criticism of Mr. Lawler's paper.

Two main facts stand out in connection with fire troubles in turbo-generators: namely, that the percentage of fires is greater in high capacity machines than in those of moderate or low capacity; and that fires are relatively much more frequent in high voltage machines than in those of low voltage.

As small capacity machines have been in use for a much longer period than those of large capacity, the latter being of comparatively recent date, it would appear that if age of the unit, or of the insulation, were of first importance in causing fires, there should be a preponderance of fires among the older and smaller units. But such does not appear to be the case, and apparently a principal cause must be looked for elsewhere. Presumably this lies in the greater energy liberated in the case of a short circuit, together with the vastly greater ventilation in the larger units.

If a short circuit occurs in a large unit, the electromotive force producing such short circuit cannot be reduced instantly by cutting off the excitation from the field, for it takes an appreciable time for the field magnetism to die down. This is especially the case in the large, solid rotors, which are now extensively used in such machines. Therefore, if a short circuit, resulting in an arc, is established, the energy expended may be enormous, as Mr. Lawler has pointed out, and, even if the field excitation is very quickly cut off, the expenditure of energy may still last for a period sufficient to establish a fire in the end windings. Apparently there is heat enough in such short circuits to "gasify" the insulating varnishes in the neighborhood of the arc, and if this condition is once started, it seems to spread rapidly.

A series of tests was made under my direction to determine whether an asbestos taping over the outside of the end windings would so delay the combustion that the fire might be extinguished without doing any great damage. However, these tests showed that when an arc is once started, sufficient to gasify the varnishes, the asbestos-covered coils burned about as quickly as the others. In fact, there was no encouragement whatever in our tests.

This does not mean, however, that some more effective protective covering may not be developed at some future time. Attention is called to the fact, however, that present available materials, such as asbestos tape, might ultimately represent more of a danger factor than a protection, as has already been referred to by Mr. Lawler. Some very costly experiences have been encountered by electrical manufacturers in the use of asbestos tape as an outside protecting covering in other than turbo-generator apparatus.

As to the second fact stated, that a far greater percentage of fires occurs in high voltage machines, this needs no particular amplification. While a low voltage machine might give as much energy on short circuit as the high voltage machine, yet such short circuits are less liable to happen inside the machine. Moreover, the low voltage machine has relatively less insulation on its end windings, and therefore there is less tendency to formation of combustible gases. Moreover, the majority of large capacity machines are wound for relatively high voltage, and, as stated before, the larger percentage of the fires occurs in the larger units. Thus the questions of capacity and voltage are so related that it is difficult to say whether either one is more responsible than the other for fire damage.

As to the effect of age on the fire risk, experience has not yet shown definitely that comparatively old machines are liable to suffer from a fire to any greater extent than new ones. This may be due to the fact that old, well baked and well dried insulations do not seem to be as readily combustible as new "green" insulations. The latter will probably generate gases more quickly than the thoroughly seasoned material. Therefore, as far as the insulating material itself is concerned, age should probably make the conditions no worse. However, accumulations of oil, dust and other foreign materials on the end windings, should make the conditions somewhat worse.

As to fire protection, Mr. Lawler's suggestions are to the point, and the remedies which he proposes should be effective to a certain extent. However, a number of things should be taken into consideration in this matter. He suggests, for instance, automatically cutting off the air supply by closing the inlet, and thus allowing only the leakage air to pass through the machine. This remedy should be fairly effective if the leakage can be made small enough. For instance, a 20,000-kw. turbo generator unit may have 50,000 to 75,000 cu. ft. of air per minute blown through it, in normal operation: this is vastly more than required to maintain combustion if a fire is once started. Even if the main inlet pipe is very completely closed, there might be a leakage of possibly 1 per cent through joints in the inlet valves, in the end housings of the machine, and at other points. This would mean 500 to 750 cu. ft. of air per minute through the machine, which would probably be ample to maintain a very damaging fire.

Furthermore, with even a relatively slight percentage of the normal quantity of air leaking into the machine, it is obvious that a small amount of carbonic dioxide gas would have but little effect. Therefore, the gas would have to be supplied either in great volume, or the air leakage must be made exceedingly small, in order that the gas may become effective. The problem is further complicated by the fact that, in some designs of machines, the chambers containing the end windings are normally under pressure which resists the flow of any extinguishing gases into such chamber, unless fed in at the ventilating fan or fans. In one case which I have in mind, where a fire occurred in the end winding, an attempt was made to introduce gas into the end housing, but without success, on account of the high internal pressure. The only effective extinguisher, in this particular case, was the use of a fire hose with the city water pressure behind it. This put out the fire, but the damage was almost as great as if no extinguisher had been used.

It should be remembered that the fumes from the fire are, in themselves, a good extinguisher, and therefore, if these fumes can be kept inside the machine, combustion will either be stopped or very much retarded. Therefore, one

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remedy which has been proposed at times is to not only close the inlet in case of fire, but also to close the outlets. This may be difficult to accomplish practically, but should be fairly effective.

In the usual turbo-generator, the ventilating fans form part of the unit itself, and the ventilating tendency or action is present until the machine is shut down. However, in some recent machines of very large capacity, separate blowers are provided, and where such is the case, some automatic means might be provided for shutting down the blower when a fire is started in the machine. In such an arrangement, the effect of leaks would be very much less pronounced than in machines with self-contained blowers. However, a note of warning should be sounded in connection with all automatic devices which affect or control the ventilation of large turbo-generators. I refer to the fact that such devices, if they act improperly, may cause the very trouble which they are intended to remedy. Large turbo-generator units are so dependent upon artificial ventilation that they may overheat very quickly, and thus cause a fire, in case the ventilation is accidentally shut off, even for a short time. Therefore, if the fusible links mentioned by Mr. Lawler should act, through some defect, to close the inlet passages, or cut off the normal ventilation, and this were not discovered quickly, overheating might result.

Obviously, with such automatic devices, a signaling or indicating system should be used, which at once will call attention to the fact, when the air supply is cut off. So important is the supply of air to such machines under normal operation, that it is recommended, where separate ventilating fans are used, that these be driven by motors operated directly from the machines themselves, so that whenever the voltage is on a machine, its blower will automatically be kept in operation. One interesting feature in such an arrangement is that, in case of a short circuit, either inside or outside the machine, which tends to kill the voltage, it also tends to shut down the blower. In this way the power is automatically cut off the ventilating fan.

In conclusion I may say that, at present, the problem of protecting such a machine is one of completely closing the inlets or the outlets, or preferably both. If power station designers would give as careful consideration to these points as is given to many other points in station design, the risk of fire damage in turbo-generators could be greatly reduced.

J. E. Moultrop (written). Mr. Lawler's paper points out some of the inherent defects of modern turbo-generators, but I question the value of the remedies he proposes. Modern turbo-generators run at a high rate of speed, the windings are as compact as possible, the windage of the machine is high and the insulation is quite inflammable; consequently there is a remarkably short interval between the time when the disturbance first starts and when the major portion of the exposed surface of the insulation is on fire. As soon as this takes place, the damage from an electrical standpoint has been done. I believe the practical solution of this problem is to bring all possible influence upon the manufacturers to devise and install non-combustible insulation, and I understand that there is some prospect of such insulation being brought out in the near future.

Paul M. Lincoln. Mr. Lawler says that the short circuit current of generators rises, in some cases, to as high as forty times the full load current. Although some turbo-generators have a short circuited current as high as that, it is not true of the modern turbo-generator. The designs put forth today will have a short circuit current of a value of somewhere between ten times and twenty times full load. This result is obtained by designing the generator so that the inherent reactance of the generator windings is higher than it is in slow-speed generators.

There have also been marked improvements in the method of bracing the generator winding so as to prevent motion under the tremendous mechanical strains that take place therein. I believe that I am perfectly safe in making the statement that so far as the protection against a mechanical stress due to short circuit is concerned, the modern generator does not require the addition of choke coils in order to make it safe, as suggested by Mr. Lawler.

I should like to ask Mr. Lawler whether it is the practice of the fire underwriters to insure generator windings against fire hazard originating within themselves? It is possible and in fact is standard practice, to install generators so that the windings can be completely consumed without any great fear of the fire communicating to the other parts of the building. So that a fire, if it does occur, may simply destroy the windings of the turbo-generator itself, without any great risk of its communicating anywhere else.

Forrest E. Cardullo. It has been suggested that carbon dioxide be introduced into the air ducts of a turbo-generator for the purpose of smothering a fire, but it seems to me that it would be more practicable to introduce steam for this purpose. To do so, it might be convenient to bleed the turbine at a point where the pressure is 15 to 30 lb. gage, and to introduce the steam into the air duct through some form of diffuser. An equally satisfactory method would be to pass steam from a saturated steam line through a reducing valve. The control of the steam might be automatic, so that the steam would be introduced by the melting of a fusible link, in the same manner as is proposed for the closing of the damper. I would call attention to the fact that the fusible links ought to be placed in the exit duct as close as possible to the generator; on this account, it would probably be better to have the damper placed in the exit duct than in the inlet duct.

H. G. Reist (written). Having been intimately connected for many years with the design and construction of turbo alternators, I have found this paper very interesting, and, in general, I agree with the views set forth in it.

It is true that some protection can be gained by the use of fire-resisting materials on the end of windings, but we must not expect too much from this because most varnishes are more or less combustible, and the fire-resisting materials, such as asbestos or mica, are too much divided to offer a complete barrier against the flames passing through them. At one time my attention was called to the fact that a cement floor when soaked with oil burns as well as a wooden construction, and the same holds true of the insulating material on turbo-windings.

It has been pointed out that it is difficult to introduce an inert gas into turbo-generators. This difficulty could, however, be overcome by introducing the gas in front of the fan, instead of beyond it, so that it would be drawn in by suction.

Another possible means of protecting these machines is to arrange a damper in such a way that it will not only close

the inlet, but short circuit the outlet to the inlet, so that the additional air taken in will be air which has already passed through the generator, and, therefore, has its oxygen consumed. In European practice, where cotton filters have been used universally, there is danger of fire, and dampers have lately been introduced. How effective they are I cannot say. I have constructed dampers in some cases for turbo-generators, as long as six or seven years ago, but have not felt their utility sufficient to warrant the increased expense of using them generally.

So great have been the improvements in turbo-generators that fires are rare. Furthermore, the enclosed construction used on this type of machines makes it practically impossible for the fire to spread to the building.

Selby Haar. With regard to non-combustible coverings on the windings, it is perfectly feasible to get a non-combustible insulation, but the trouble is that non-combustible materials are usually pretty good heat insulators, and keeping the heat in his machine is just exactly what the designer is trying to avoid.

A. Blauvelt. Judging from the preceding discussion there is a difference of opinion and a lack of real knowledge as to how quickly the copper gets hot and how much copper is really affected as compared to the whole of the copper. Mr. Lawler's fourth suggestion for the introduction of a dead gas indicates that the arcing does not usually immeditely heat so much copper as necessarily to fry the entire machine before the copper could cool. On this assumption I would make two suggestions: (*a*) that a more prompt action at a lower heat can be secured by an ether pulse glass, or several of them, than by a fusible link or links; (*b*) that chimney flue gas is a good dead gas always available in large quantity, for example, as used by the Union Carbide Company. The particular details of solenoids, and relays, of dampers, cooling tank, pressure blower, exciting circuit breaker, etc., are a matter of expense and should or should not be gone into depending on whether the annual direct and indirect losses through these particular fires do or do not exceed 20 per cent on the cost of the protective equipment necessary to cover all the machines in service.

Roger De Wolf.[1] In view of a recent experience in the burning out of a machine, I should like to hear from Mr. Lawler as to just how much he thinks the different methods suggested of cutting off the air supply and introducing carbon dioxide would reduce the damage to the machine. As pointed out by Mr. Moultrop, the time element is very short and there are a lot of things which might be done if there was time to do them, but in actual practice I believe the operating force would never get them done. In our case the short circuit resulted in burning off the main leads to the machine, and even if the air supply had been shut off, or the interior of the machine filled with carbon dioxide, I think the damage would not have been very greatly decreased. The amount of heat generated in the machine in a very short period of time is so great that the carbonization of the insulating material would be carried to quite an advanced stage, and although the actual combustion might not take place on the exterior surface, the insulation on the windings would be practically destroyed, irrespective of whether there is an atmosphere around those windings which would support combustion or not.

The Author. While it may be, as Mr. Lamme states, that there is no experience as yet showing that old machines are more liable to fire damage than new ones, it must be remembered that but very few turbo-generators can yet be considered old. This type of machine has only just passed through the development stage and therefore many new ones have given trouble, sometimes resulting in fire. In the future less trouble may be expected with new machines, but as they get older, the ordinary indication of age, such as short circuits, etc., may be looked for. It is reasonable to suppose that most machines will not be replaced until one or more short circuits have occurred, and owing to the condition pointed out by Mr. Lamme and by myself in the paper, fires will probably occur in many instances.

It is undoubtedly important that means be taken to keep air leakage down to an inappreciable amount, so that the atmosphere in the machine will not support combustion after the carbon dioxide gas is introduced. Some leakage would of course be expected but to offset it, the carbon dioxide gas should be admitted in abundant quantities. It is not necessary that all gas within the generator be carbon dioxide that a fire be extinguished, for I understand that a mixture consisting of 25 per cent carbon dioxide and the remainder air, will form an atmosphere in which fire cannot exist. The exclusion of air and admission of the inert gas are details which can undoubtedly be satisfactorily worked out.

Regarding Mr. Lincoln's question as to the practice of fire insurance companies covering damage by fire to electrical apparatus when fire starts from electrical causes within the apparatus, I cannot answer for all companies, but it is my belief that policies very seldom cover such loss. The fact that policies do not cover such loss makes it even more important from the standpoint of the owners of turbo-generators that fires be prevented in their machines.

Professor Cardullo suggests the use of steam for extinguishing generator fires. Steam may have the advantage that large quantities will be quickly available, but it has the disadvantage that it will thoroughly wet down the windings and in the case of old machines it might be difficult to avoid rewinding them, if they are wet down.

I have recently heard of some experiences which would indicate that steam was not as effective in extinguishing fire in enclosed places as has generally been thought. Carbon dioxide gas would extinguish fire more efficiently than steam, and being dry would not of itself cause injury to the machines.

In reference to Mr. DeWolf's question, the methods suggested in the paper are only to prevent occurrence of, or damage by, fire to the machine. They would not have any effect on the possible roasting of the insulation by continued heavy currents flowing in the winding. Short circuits have occurred in turbo-generators many times and probably most of them have not resulted in fire damage. It is probably a fact that where fire has not resulted, repairs to but a portion of the coils have usually been necessary and this would indicate that only in a small proportion of cases has it been necessary to rewind machines, due to a general roasting of insulation from the passage of current itself.

If the operators open the switches within a reasonably short time, as has appeared to be true in most cases in the past, roasting by current would not occur and it would appear well worth while to save the insulation from fire damage.

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EXTINGUISHING OF FIRES IN OILS AND VOLATILE LIQUIDS

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The extinguishing of fires in oils and in most of the volatile liquids has always been a difficult problem and where fires of this kind occur the results are frequently very disastrous. Our most common extinguishing agent, water, works rather unsatisfactorily upon the majority of such fires, but it is still the only one available where heroic measures are required. Comparatively recently, however, there have been two or three other materials introduced for use as extinguishers which have shown some promise for dealing with these fires, and it is the purpose of this paper to discuss these materials and the conditions under which they prove the most efficient.

Not all fires in volatile liquids are difficult to handle with water. When the liquid is miscible with water this extinguishing agent can be successfully used. Examples of this kind are denatured alcohol, wood alcohol, grain alcohol, acetone, etc. Where the liquid is not miscible with water little or no effect is produced except to wash the burning liquid out of the building where it may be completely consumed or, if the quantity of oil is small, possibly to extinguish the fire by the brute cooling effect of a large quantity of water sprayed upon the fire. Soda and acid extinguishers are somewhat more effective than pure water, but even they fail under most conditions. The various grenades containing salt solutions which were formerly extensively exploited are of course practically worthless.

The only principles that can be made use of in extinguishing fires in volatile oils are, (*a*) to form a blanket either of gas or of solid material over the burning liquid which will exclude the oxygen of the air, or, (*b*) to dilute the burning liquid with a non-inflammable extinguishing agent which is miscible with it.

SAWDUST AND BICARBONATE OF SODA

To the blanketing type of extinguishers belongs sawdust. Paradoxical as it may seem, ordinary sawdust is an excellent extinguishing agent for certain volatile liquids, especially those of a viscous nature. A considerable number of experiments were conducted in the fall of 1912 by the inspection department of the Associated Factory Mutual Fire Insurance Companies, in the extinguishing of fires in lacquer and gasolene in tanks with sawdust, and the results were surprisingly satisfactory.

The liquids were placed in three tanks 30 in. long, 12 in. wide and 16 in. deep; 48 in. long, 14 in. wide and 16 in. deep; and 60 in. long, 30 in. wide and 16 in. deep. The sawdust was applied with a long-handled, light but substantially built snow shovel having a blade of considerable area. In every case the fires were extinguished readily, especially in the two smaller tanks which were about as large as any ordinarily employed for lacquer in manufacturing establishments.

The efficiency of the sawdust is undoubtedy due to its blanketing action in floating for a time upon the surface of the liquid and excluding the oxygen of the air. Its efficiency is greater on viscous liquids than on thin liquids, since it floats more readily on the former than on the latter. The sawdust itself is not easily ignited and when it does become ignited it burns without flame. The burning embers have not a sufficiently high temperature to reignite the liquid.

The character of the sawdust, whether from soft wood or hard wood, appears to be of little or no importance, and the amount of moisture contained in it is apparently not a factor, so that the drying out of sawdust when kept in manufacturing establishments for a time would not affect the efficiency.

It was found that the admixture of sodium bicarbonate greatly increased the efficiency of the sawdust as shown both by the shortened time and the decreased amount of material necessary to extinguish the fires. A further advantage of the addition of bicarbonate of soda is that it decreases the possible danger resulting from the presence of sawdust in manufacturing plants since it would be difficult, if not impossible, to ignite the mixture by a carelessly thrown match or any other ready source of ignition.

Although the efficiency of the sawdust is greatest on viscous liquids such as lacquers, heavy oils, japan, waxes, etc., in the tests referred to, fires were extinguished in gasolene contained in the smallest tank and also when spread upon the ground. In larger tanks the sawdust or bicarbonate mixture does not work so well since the sawdust sinks before the whole surface can be covered, whereupon the exposed liquid reignites.

CARBON TETRACHLORIDE

In recent years carbon tetrachloride has received considerable attention as a fire-extinguishing agent. This is due largely to the activity of certain manufacturers of fire extinguishers which use liquids, the basis of which is carbon tetrachloride.

This substance is a water white liquid and possesses when pure a rather agreeable odor somewhat similar to chloroform. A considerable proportion of the commercial article upon the market, however, contains sulphur impurities which impart a disagreeable odor to the liquid. The substance is quite heavy, its specific gravity being 1.632 at 32 deg. fahr. It is non-inflammable, non-explosive, and is readily miscible with oils, waxes, japan, etc. When mixed with inflammable liquids it renders them non-inflammable provided a sufficient quantity is added. Its vapor is heavy, the

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specific gravity being about five and one-half times that of air, consequently it settles very rapidly. As an extinguishing agent it operates by both the principles mentioned above, namely, it dilutes the inflammable liquid rendering it non-inflammable, or at least less inflammable, and it forms a blanket of gas or vapor over the burning liquid which excludes the oxygen of the air.

Although this paper is confined to a discussion of extinguishing fires in oils and volatile liquids, it may not be out of place to mention that the claims made by certain manufacturers producing extinguishers which use liquids, the basis of which is carbon tetrachloride, are grossly exaggerated. These preparations, none of which is more efficient than carbon tetrachloride, are not the equivalent of the ordinary water extinguishers for general use on such materials as cotton, wood, paper, oily waste, etc.

On volatile liquids, oils, etc., carbon tetrachloride has, however, shown very satisfactory results under some conditions, but the readiness with which a fire can be extinguished with it depends to a considerable extent upon the skill of the operator and the nature of the fire. In tank fires the length of time that the liquid has been burning is an important factor, and in such cases where the sides of the tank become heated the only way in which the fire can be extinguished is to squirt the liquid forcibly at the sides. If the carbon tetrachloride is squirted directly into the liquid it is much more difficult, if not impossible, to extinguish the fire.

The height of the liquid in the tank is also a very important factor. Where the liquid is low the sides form a pocket which retains the vapor and aids considerably in smothering the blaze. When the tank is nearly full, however, this condition does not exist, and it is then very difficult, if not impossible, to extinguish a fire in a highly volatile liquid, such as gasolene; only the most skilled operators are successful in these cases. The size of the tank or the extent of the fire if upon the floor is, as would be expected, of considerable importance. In tanks larger than about 28 in. by 12 in. more than one extinguisher and operator working at a time are necessary to extinguish a fire in such materials as gasolene. In one test where a tank 60 in. by 30 in. was used no less than seven operators were necessary, and even then it was only with the greatest difficulty that the fire was put out.

All of the above remarks apply to carbon tetrachloride in the ordinary one-quart extinguisher as generally sold. It is probable that a large extinguisher which could throw a large stream would prove more efficient, but on account of the great weight of carbon tetrachloride such an extinguisher would have to be specially designed to make it readily portable by mounting on a truck or some similar means. Expelling the liquid by means of a hand-pumping arrangement would probably be unsatisfactory, and it would therefore be necessary to force it out in some other way.

A few systems have recently been installed in which an elevated tank containing carbon tetrachloride was connected with automatic sprinklers or perforated pipes located in hazardous rooms where volatile and inflammable liquids are in use. So far as is known none of these systems have as yet been called upon to extinguish a fire, but there appears to be no reason why such a system should not provide excellent protection in special cases. In such systems it would be necessary to consider the safety of the workmen and furnish ready means of escape, since carbon tetrachloride is an anesthetic and where thoroughly sprayed through the air as from an automatic sprinkler it would probably produce rapid results.

The nature and effect of the fumes given off when carbon tetrachloride is thrown upon a fire is a subject which has received a great deal of discussion. When the liquid comes in contact with a fire the vapor is partly decomposed resulting in the evolution of a considerable quantity of black smoke which is undoubtedly finely divided carbon. Pungent gases are also produced which appear to be mostly hydrochloric acid with possibly a small amount of chlorine. Since carbon tetrachloride contains no hydrogen from which hydrochloric acid could be formed this substance must be produced by the action of chlorine on the gases arising from the burning material or upon the moisture of the air.

The fumes of carbon tetrachloride although of a very pungent nature do not produce any permanent injury under ordinary conditions where the operator can make his escape after he has inhaled all that he can stand, but they are a distinct handicap in fighting a fire and are one of the objectionable features to carbon tetrachloride as a general fire extinguishing agent. In large rooms or where a small quantity of carbon tetrachloride is sufficient to extinguish a fire the gases are of course less objectionable.

FROTHY MIXTURES

Another method of extinguishing fires in oils and volatile liquids which has recently been proposed and experimented with is that of using frothy mixtures. The idea seems like a very promising one and the tests which have been thus far reported indicate very satisfactory results. The idea was originated and has been developed in Germany. So far as is known no experiments have been conducted in this country.

The process consists essentially in causing two liquids to mix in a tank where foam is produced. The tank is made air-tight and sufficiently strong to permit of the foam being forced out by carbon dioxide under pressure, and the foam is conveyed to the fire by means of a line of hose. The exact nature of the liquids has not been disclosed, but one of them probably consists

of a sodium carbonate solution containing froth-forming ingredients such as glue or casein and the other an alum solution. The two on coming together generate carbon dioxide which produces froth. This froth is reported to be quite stiff and to shrink in volume but a comparatively small amount even after a period of half an hour.

A number of tests were conducted in the winter of 1912 in Germany; some of them on a considerable scale. In one case as much as 5 tons of crude naphtha in a tank was involved, and in another an area of 1300 sq. ft. of burning tar was used. In all cases the results were reported satisfactory, the fires being extinguished in a short time.

The frothy mixture undoubtedly owes its efficiency to its blanketing action in settling upon the surface of the burning liquid, thus excluding the oxygen of the air, and to the fact that the bubbles of liquid contain carbon dioxide which upon bursting produce an atmosphere in which combustion cannot take place.

According to the latest reports the matter is still in an experimental stage, various details regarding the form of apparatus, most efficient pressure, and design of nozzles being under consideration; but from what has already been done it would appear that the idea is a very promising one, and that this method of extinguishing fires in oils and volatile liquids will prove to be by far the most efficient of any that has as yet been suggested.

DISCUSSION

A. E. Cluett. As I understand it, the tank was an open one, of rectangular section, which does not represent the conditions in which these liquids are ordinarily found. They are generally in a closed tank, with a bung-hole of some description, and I would like to ask whether any experiments have been made on such receptacles, and also whether experiments have been conducted where the fluid has been spread out as it would be if it were spilled over a floor.

J. Stewart Thomson (written). The author of the paper occupies a position in connection with an organization insuring sprinklered risks, which makes no recognition whatever of devices for the extinguishing of fires other than by sprinklers. His remarks are the result of some tests made by him in connection with devices other than sprinklers.

It is generally known that fires in volatile liquids which are not miscible with water cannot be extinguished by the application of water. The reason is perfectly apparent; and that the way to extinguish a fire in volatile liquids of this type is to blanket the flame or to dilute the liquid with a non-inflammable extinguishing agent thus cooling the liquid to the point where it will not burn.

The use of sawdust in connection with fires of this character is not new. Almost every one has at one time or another used a blanket, towel or something similar for the purpose of smothering a fire. We all know that sawdust will float for a time at least on the surface of the liquid, and that if the sawdust is put on in quantity it acts as a blanket. As a practical fire extinguishing agent, however, the use of sawdust is not practical. In a large tank of burning liquid of the type described, before the surface can be covered with the blanket, much of the sawdust will sink below the surface whereupon the exposed liquid reignites.

As to the use of carbon tetrachloride as a means of extinguishing fires in oils and volatile liquids, there are some 40 different devices on the market employing this substance. Carbon tetrachloride has been found to be remarkably efficient; a quart of this liquid contains approximately 149 cu. ft. of fire extinguishing gas. As Mr. Barrier states, carbon tetrachloride contains sulphur impurities. Its use in a metal container results after a period of time in the corrosion of the metal. Extinguishers generally employing this chemical have not been found to have long life and corrosion of the metal results in the clogging of the working parts of the extinguisher. These extinguishers have the additional drawback of operating by air pressure; it is a well-known fact that air cannot be contained over any very long period in a metal container with valves, outlets, petcocks, etc.

The manufacturers of the Pyrene extinguisher discovered the efficiency of carbon tetrachloride as an extinguishing agent many years ago, but also that this article is corrosive in its action upon metals. It was necessary to alter the nature of carbon tetrachloride in respect to this before it could be used successfully in a fire extinguisher. They also discovered that it was possible to increase the efficiency of the liquid.

While the claim is not made by the author, the inference would be from his paper that carbon tetrachloride is virtually the same as the extinguishing agent employed by the Pyrene Manufacturing Company, in his reference to "the activity of certain manufacturers of fire extinguishers which use liquids, the basis of which is carbon tetrachloride." He is probably not informed that one quart of Pyrene will generate approximately 33 1-3 per cent more fire extinguishing gases than carbon tetrachloride; therefore it will cover more fire. The one-quart pump-type Pyrene extinguisher has been approved by the Chicago Laboratories, Inc., and is in universal use throughout the country; is uniformly recognized in every state for fires of the type described by him, and that its record of efficiency in respect to these fires is remarkable.

In stating that "these preparations, none of which is more efficient than carbon tetrachloride, are not the equivalent of the ordinary water extinguishers for general use on such materials as cotton, wood, paper, oily waste, etc., Mr. Barrier ignores the fact of the amount of extinguishing gas referred to above. Extinguishers of this type are more efficient in cotton fires and fires in oily waste, etc., than those employing solutions of water.

In the test where a 60 in. by 30 in. tank was used, where it required a number of operators to extinguish a fire of burning gasolene, he surely should have had no difficulty in extinguishing a fire in a tank of these dimensions if the extinguisher had been properly handled.

Mr. Barrier concludes that the use of soap-suds, described as "frothy" mixtures in extinguishing fires in oils and volatile liquids, will prove by far the most efficient of any that has yet been suggested, but statistics will not bear out the conclusion. This method has been employed to some extent on the Continent and in England for some time and experiments have also been conducted in this country which are

the subject of extensive reports. The progress of extinguishers working on this principle, however, has been inconsiderable as compared with the progress of other extinguishers, and notably, as compared with the progress made by the Pyrene extinguishers.

Henry W. Appleton. I would ask Mr. Barrier what he considers the proper proportion of soda carbonate in the sawdust, and what effect is produced on the sawdust to make it non-inflammable; that is, not only the percentage to be used to make it efficient in putting out the fire, but also the percentage to be used in rendering the sawdust itself non-inflammable.

Lewis H. Kunhardt. Mr. Thompson's statement, that the author occupies a position in connection with an organization insuring sprinklered risks, which makes no recognition whatever of devices for the extinguishing of fires other than by sprinklers, needs modification. It is absolutely at variance with the fact. Not only do the mutual companies give credit for many, and practically all devices which are used in extinguishing fires, but all the various sprinkler risk associations, underwriters and others throughout the country, are continuously studying all these other devices. Sprinklers are only a part of the fire protection of a piece of property. If other devices fail, the sprinklers come in and assist, and if the sprinklers should fail, there are the fire pumps, hose, etc. All the various fire protection engineers in the country are studying these problems and details thoroughly, and they do not give recognition *only* to the automatic sprinkler, although they recognize the value of it, and know it to be one of the best fire fighting agencies of today.

A. Blauvelt. As just commented by Mr. Kunhardt, this paper by Mr. Barrier covers a subject in itself and one which is not tied to automatic sprinkler practice. The use of hand apparatus is universal in all branches of fire protection practice in preference to waiting for sprinklers to fuse, or to waiting for hose, and the greatest success of the professional fire department so far as the majority, or some 70 to 80 per cent of the fires numerically are concerned, is accomplished with hand appliances, or usually the carbonic-acid gas extinguishers carried on the man's back as he jumps off the hose cart.

The general scope of hand apparatus is fairly broad, depending on the combustible to be dealt with and whether ceiling as well as floor fires are likely to need extinguishment. Under its title, the teaching of Mr. Barrier's paper would seem to be that this subject of handling oil or volatile or chemical fires is not a mystery. Doubtless, as suggested by a preceding speaker, the paper can be bettered by giving more detail as to the best proportions for the several useful mixtures, but the main thing is that those who will can make up effective extinguishing compounds for volatile liquid or oil fires, not perhaps of the exact alchemic virtue of the trade compounds but probably obtain twenty times the quantity at like cost.

Gorham Dana.[1] This paper seems to cover the field remarkably well, but there is one point I would like to bring up in connection with carbon tetrachloride, and that is the effect which the gas might have on metals in the vicinity. At a fire some time ago in a garage, an attempt was made to extinguish a pail of burning gasolene with these extinguishers. They not only failed to extinguish the fire, but the gases given off were of such a corrosive nature, probably hydrochloric acid, that the damage done to the metal work on the automobiles and in the garage, was more than the direct loss from the fire itself.

F. E. Cardullo. The claim has been made in this discussion that one quart of carbon tetrachloride at atmospheric pressure liberates a volume of 149 cu. ft. of inert gas. A hasty calculation based upon my memory of the density of air gives for the volume of carbon tetrachloride vapor liberated from one quart of liquid a value of approximately 8 cu. ft. From the data given by Peabody in his steam tables, the volume of saturated vapor liberated at atmospheric pressure from one quart of carbon tetrochloride is 9.97 cu. ft. From data based upon the theoretical vapor density of carbon tetrochloride the volume of the vapor generated from a quart of the liquid at a temperature of 135° fahr., and a pressure of one atmosphere, is 9.8 cu. ft.

It may be added that if the gas given off occupied a volume of 149 cu. ft., it would be so light as to rise in the air and would have no smothering effect upon the fire. I would suggest that, in discussion, our members ought to be exceedingly careful of their facts, and not to quote any figures, or to make any statements, of the truth of which they are not absolutely certain.

The Author. Replying to the question of Mr. Cluett, all the experiments with these materials were tried in open containers, since that is the way lacquer is ordinarily used in most metal-working plants. The metal parts are generally dipped into the lacquer. No tests were tried on closed tanks, and it would be difficult to use sawdust and bicarbonate of soda in such a tank. It might be possible to introduce carbon tetrachloride under such conditions. One of the tests did include a fire in lacquer spread over a wooden platform which served as a floor, and the sawdust appeared to work very satisfactorily in this case.

With reference to the comments of Mr. Thompson, I would say that I recognize that sawdust as an extinguishing agent is not new, but it is not well known, and this fact is shown by the experience we have had where this material has been recommended to manufacturing establishments throughout the country. At first their attitude was one of great surprise but after they had conducted a few tests of their own, they were very well pleased with the results. This shows that even though the idea may not have been new, it was at least not at all well known and the feature of mixing bicarbonate of soda with the sawdust is a new and valuable one.

It was not my intention to mention any particular commercial device, but in view of the fact that the Pyrene extinguisher has been brought into the discussion, I will say that with reference to the matter of the corrosive action of carbon tetrachloride, tests were conducted in a Pyrene extinguisher with an ordinary garden variety of carbon tetrachloride, the usual commercial article, in which the liquid remained in the extinguisher for over a year, but as far as could be seen after using a can opener there was absolutely no indication of corrosion. In certain cases where moisture or hydrochloric acid are present, carbon tetrachloride does cause some corrosion, but the indications are that if

[1] Manager, The Underwriters' Bureau of New England, 141 Milk Street, Boston.

a reasonably pure grade of the material is obtained, there is no serious trouble from this source.

As to the comparative efficiency of Pyrene and carbon tetrachloride, a large number of tests were made to compare the two liquids when both were used under the same conditions. As far as a number of unprejudiced observers could determine, there was no difference in the efficiency of the two. It is true that Pyrene contains a few other substances besides carbon tetrachloride, among which is a small amount of gum, which by the way is combustible, and a small amount of nitro benzol which is also combustible; both of these are detrimental rather than advantageous as far as extinguishing a fire is concerned.

With reference to the proportions of bicarbonate of soda and sawdust, the ingredients are mixed in the proportion of about 8 lb. of bicarbonate of soda to a bushel of sawdust. This proportion does not render the sawdust noncombustible but it does retard its ignition. It works in the following way: If a spark or any other source of ignition comes in contact with the mixture in the vicinity of where the bicarbonate of soda is located, the latter becomes heated and begins to give off carbon dioxide. This tends to make the atmosphere in that vicinity a non-supporter of combustion and serves to extinguish or retard the fire.

In reply to the question by Professor Woolson as to whether there is any tendency toward caking after the sawdust and the bicarbonate of soda have been standing for any length of time, I may say that this feature has been pretty thoroughly tested under the worst possible conditions and after a period of six or eight months hardly any indication of caking could be detected.

A SYSTEM FOR THE CONTROL OF AUTOMATIC SPRINKLER VALVES

By Fred J. Miller, New York
Member of the Society

Experience seems to have proved abundantly that the best of all means of fire protection is the automatic sprinkler. In theory, at least, it is supposed to be always ready for instant use, and it puts water where and when it is needed at the very beginning of a fire, before it has had time to assume threatening proportions, and usually before there is enough smoke to alarm the occupants of the building seriously or start a panic.

Every risk covered by the Manufacturers' Mutual Fire Insurance Companies must be protected by automatic sprinkler heads. It is impressive to note that the 19 companies, comprising what is known as the senior group, carry policies on industrial establishments aggregating over $2,500,000,000; employed in these factories there are, as nearly as can be ascertained, about 2,000,000 people, and so far as known not a single life has been lost in any of the buildings thus insured where the sprinkler heads were in commission at the time of the fire. A few lives have been lost in these factories, but in every such case the fire gained headway because, for one reason or another, the automatic sprinklers were out of commission at the time.

But sprinkler heads when once installed must then be kept ready for service when needed. Sprinkler heads are usually arranged in groups with a supply pipe for each group. In each of these main supply pipes is a valve by means of which water can be shut off from that section when necessary for repairs or by reason of the opening of one or more sprinkler heads, either in performing its normal service, or by accident. These valves cannot be locked open because it may be necessary in an emergency to close them as quickly as possible.

These valves introduce an element of danger and with this it is the main object of this paper to deal.

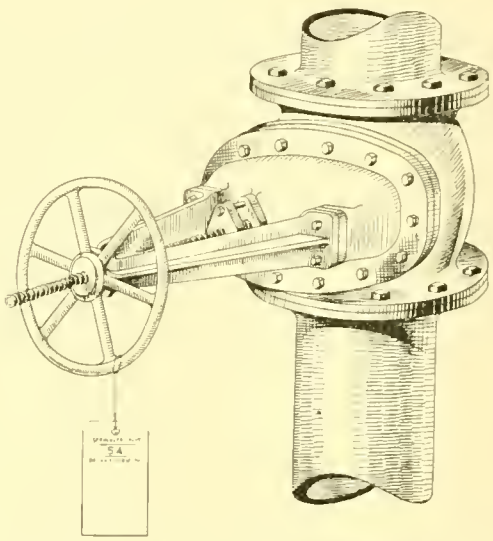

Fig. 1 Sprinkler Valve Open with Instruction Tag Attached

The inspectors of the Mutual Companies frequently find the valves referred to closed, and the sprinkler heads, therefore, of no more use than as though they had never been installed.

In an effort to lessen this evil, the Factory Mutual Companies occasionally send to their policy holders a circular letter on the subject of the danger of closed sprinkler valves. In a report, covering the months of April, May, June 1912, 72 cases were reported where inspectors found such valves closed. In 63 of these cases the number of sprinkler heads controlled by the closed valves are given, and these foot up to 8274 heads. Assuming that the cases in which the number of heads is not given would average about the same, this means that for this report, covering these months, nearly 10,000 sprinkler heads were found out of use by reason of valves closed when they should have been open.

In many cases no reason was assigned for the valves being closed, which means, we may infer, that the proprietors did not know how the valves came to be closed. It is inconceivable, of course, that they would go to

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the expense of installing automatic sprinklers and other fire protective devices, and then allow them to be thrown out of use if they had the organization and the discipline necessary to keep such devices always available.

The Remington Typewriter Company owns and operates five factories on which it carries in the Mutual Companies insurance policies aggregating about $6,000,000. These factories are protected by nearly 10,000 sprinkler heads, the water supply for which is controlled by 84 valves.

We have had from the start a system of inspection under which a watchman at frequent intervals examines each valve to see whether or not it is open. If found closed, the reason therefor is investigated, a report is made and an effort made to prevent a repetition of the error.

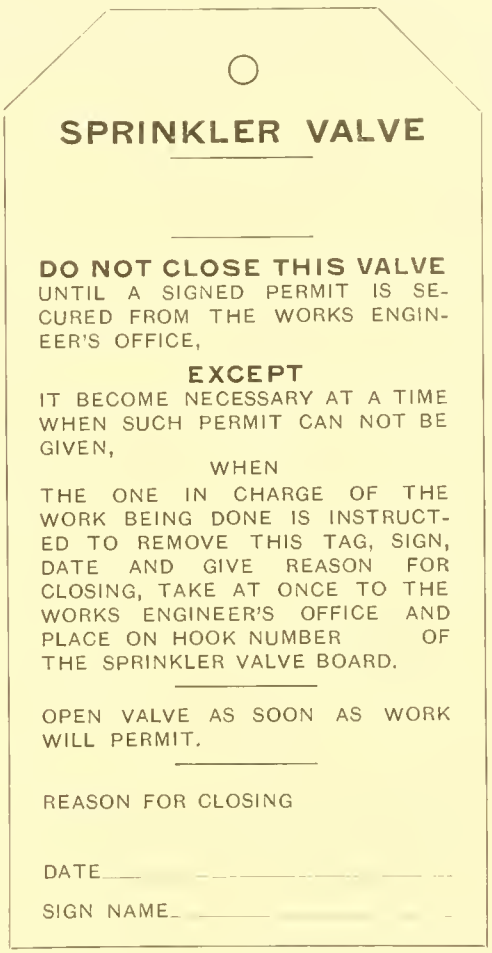
For many years no inspector of the Mutual Companies had found one of our sprinkler valves closed, until about a year ago when one was found. The reason revealed by an investigation is probable typical of a good many such cases. A mechanic had been making some repairs in a boiler house, over the boilers, and under the roof where the sprinklers were. Before going up over the boilers he closed the valve controlling these sprinklers as a precaution against accidental flooding. When he had finished the work he called down to his assistant to open the valve. He took it for granted that the assistant had done so, but for some reason the valve was not opened and the next day the inspector arrived.

To decrease the liability of valves being either closed without authority, or left closed when they should have been opened, we have devised and have in use in our factories the system to be described:

Our sprinkler valves are all numbered and upon each valve there is hung a tag as shown in Fig. 1. This tag is marked with the number of the valve to which it is attached, and, printed upon a tag is a prohibition of the closing of the valve without a signed permit to do so, except when, in an emergency, or for any special reason it must be closed at a time when no permit can be obtained, in which case it is to be detached and hung upon an indicator board with hook for each sprinkler valve. This is as directed by the card itself, and when it is done the blanks upon this card must be filled in to show by whom the valve was closed, when it was closed, and the reason for closing.

When such an emergency closing of the valve takes place, at a time when the person in charge of the indicator board is away, the watchman or other person having access to it goes to the board with the person who has closed the valve. Both these men then see that a red card complete but left blank is hung upon the board over the card removed from the closed valve. These are hung upon the hook numbered to correspond with the number of the closed valve. These cards thus hung upon this hook are intended to attract the notice of the person having the board in charge, who will, after proper investigation, fill out the blanks on the red card, hang the lower portion of it on the numbered hook corresponding to the closed valve, and attach the upper portion to the valve itself, alongside of the instruction tag, unless it shall have previously been re-opened.

In most cases it will be possible to obtain a written permit before closing a valve, and in such case the permit is given by the person in charge, by filling in the blanks printed upon the red tag (Fig. 3). It is then


SPRINKLER VALVE

DO NOT CLOSE THIS VALVE
UNTIL A SIGNED PERMIT IS SECURED FROM THE WORKS ENGINEER'S OFFICE,

EXCEPT
IT BECOME NECESSARY AT A TIME WHEN SUCH PERMIT CAN NOT BE GIVEN,

WHEN
THE ONE IN CHARGE OF THE WORK BEING DONE IS INSTRUCTED TO REMOVE THIS TAG, SIGN, DATE AND GIVE REASON FOR CLOSING, TAKE AT ONCE TO THE WORKS ENGINEER'S OFFICE AND PLACE ON HOOK NUMBER OF THE SPRINKLER VALVE BOARD.

OPEN VALVE AS SOON AS WORK WILL PERMIT.

REASON FOR CLOSING

DATE

SIGN NAME

Fig. 2 Instruction Tag Attached to Every Sprinkler Valve

torn in two at the dotted line, and the upper portion of it given to the person applying for the permit, who attaches it to the valve before closing it. The lower portion of the same red tag is hung upon the hook on the indicator board, numbered to correspond with the number of the valve.

The board is fastened to the wall of the room, or above the desk of the person having the system in charge, who may be the chief engineer, the superintendent, or one of his assistants, and the red tag hanging upon the hook is a constant reminder to him and a token to all others who may be interested, that the valve is closed. During this time the valve itself will have hanging upon it the red permit tag, which is a

sign and reminder so long as it remains there that the valve is closed and that the sprinkler heads controlled by it are therefore out of commission.

It will, of course, be perceived that the main feature of this system is the board with numbered hooks, which is in plain view of the factory official charged with responsibility for the sprinkler valves; a red tag upon this board is a danger signal, which means it should be taken off as soon as possible, and this can be done only by re-opening the valve. The card has written upon it the time at which it was expected that the valve could be re-opened. It is the business of the official having the board in charge, when this specified time has passed, to investigate the reason, and if a later time must be assigned, to indicate it upon the card and again take it up.

While the description of this procedure may make it seem somewhat formidable, in actual operation it is not at all inconvenient and it gives to some responsible person control of the sprinkler valves.

Of course this system of valve control is not presented under the impression that, by itself considered, it is a wonderful invention. So far as that is concerned it is no more than is being done every day for the accomplishment of various objects. It was devised to overcome a difficulty which, in view of all the conditions now existing, it seems rather important to eliminate in factories generally where sprinklers have

(SEE OTHER SIDE)

FIRE

SPRINKLERS SHUT

Attach this Tag to Valve

Valve No..... { Every Sprinkler Valve should be numbered, preferably with white paint figures at least 2 inches tall. May be on pipe close to valve.

Shut on.....191 .....M.
Day of Week Month Date Hour

By.....
Name of man who shut the valve

To be shut
Only until.....191 .....M.
Day Month Date Hour

Reason for Closing.....

.....

Closing Authorized by
Tag No. .....
Signature of Master Mechanic or other official

Don't remove this tag until valve is opened If valve is not opened at above time, fill out and attach a second tag extending time; also a third tag if need be.

Opened On .....191 .....M.
Day Month Date Hour

By..... { After opening valve take this tag to Master Mechanic's Office to be kept until next Insurance Inspector's visit.
Signature of man who opened valve

This Coupon is to be torn off and hung on conspicuous peg board in Master Mechanic's Office until tag is returned signed by the man who opened valve. After return of tag, enter date of opening on this coupon, and send it to General Superintendent's Office.

FIRE SPRINKLERS ARE SHUT OFF

In .....
Name of Building and room

At Valve No.....on.....191 .
Day Month Date

By.....
Name of man who shut the valve

To be shut
Only until.....191 .....M.
Day Month Date

Reason for Closing .....

.....

Closing Authorized by
Tag No.....
Signature of Master Mechanic or other official

Opened by.....on.....191 .
Name of man who opened valve Date

(SEE OTHER SIDE)

Fig. 3 Form of Red Card used by the Mutual Companies

(SEE OTHER SIDE)

The danger of greatest loss from Fire in factories insured in "The Mutuals" to-day comes from Sprinkler Valves improperly closed or forgotten.

On almost every day the insurance inspectors find somewhere an important Sprinkler Valve shut. Often this occurs in factories which take pride in their order and discipline.

RULES.

1. Sprinkler valves must not be closed without authority from the Master Mechanic or other official, except in case of accident, when notice must be sent at once to the Master Mechanic.
2. A tag must be filled out and attached to the valve (inside or yard) every time a valve is closed.
3. Never shut off more sprinklers than necessary, and keep off only for shortest possible time.
4. Provide for immediate turning on of water in case of fire. Where large valves are involved keep a man near the closed valve ready to open it on notice.
5. For long and important shut offs provide extra watchman to patrol shut off area and notify Insurance Companies.

The Master Mechanic or Superintendent should provide in his office a conspicuous board with hooks, for these danger signals, and with supply of extra cards. Preferably a white board with a red border marked at the top—

"NOTICE OF FIRE SPRINKLERS SHUT OFF."

This method of Coupon Danger Cards was invented and tested in the Remington Typewriter Works and appears to be the best yet devised. Its adoption everywhere is urged by the Associated Factory Mutual Fire Insurance Companies.

A supply of these tags should be kept in Master Mechanic's Office, and may be obtained free of cost from the Associated Factory Mutual Fire Insurance Companies, Inspection Department, 31 Milk Street, Boston.

A few spare tags for emergency use should be kept conspicuously placed near desk of head of each department.

Fig. 4 Reverse of Mutual Companies' Red Card

been installed; it can save property from destruction by fire and may easily save lives of those employed in factories; for that reason it is here presented. It was not devised by myself alone, but, in accordance with the regular practice in our organization, the idea of it was presented to all our factories and it was then developed and perfected by the suggestions of the superintendents of those factories, Messrs. E. E. Barney, G. B. Brand, W. N. Brand, all of whom are members of the Society, and Mr. C. W. Burges.

Mr. John R. Freeman thought so well of it that it has been recommended by the Mutual Companies, including those of which he is president, and he and his associates have added some improvements to the red card, notably by arranging it so that the coupon which has been hung upon the board to signify a closed valve goes, when the valve is opened, to the superintendent, who is thus enabled to know how much of valve closing is taking place, and the reasons for it. This, I believe, is an excellent feature. The cards are now being supplied to all policy holders in the Mutual Companies and a reproduction of them is shown in Figs. 3 and 4.

In some of our factories, there are certain valves which, with the approval of the mutual companies are closed during the winter months. As it was thought to be undesirable that a red card should hang upon the indicator board, for some months, because danger signals constantly displayed are apt to cease to convey the idea of danger, they have proposed in one of our factories to cover the red card hung upon the board under such circumstances by a green card. That may be the best way to do it, but I am inclined to think that a better way is to leave off the red card entirely from the board and to put a memorandum into a tickler file so that the matter of reopening the valve will be automatically presented to the person in charge upon a predetermined date. This memorandum may appropriately be one of the white cards shown by Fig. 2 properly filled out; but the red tag should in all cases be hung upon a closed valve.

Mr. Freeman does not think so well of the white card. We use it because by means of it, always hanging upon a valve, a person whose business it may be to close a valve can learn and become familiar with what else is required of him besides merely closing a valve and then perhaps forgetting it. In the interest of the life-saving feature, the Remington Typewriter Company will supply such cards free to all who may wish to use them. Some are printed upon cloth for use when valves are out of doors, others upon cardboard. With the cards thus supplied it will be necessary only for the factory to provide for itself, the board with ordinary screwed brass hooks, numbered as shown—to put the board up before the eyes of a responsible factory official, and then to see that the system is used. And it is safe to say that if an owner finds that this or some such system cannot be maintained in effective operation, it may be taken as a symptom of the need of better organization in that factory.

DISCUSSION

George I. Rockwood. As Mr. Miller points out in his very interesting paper, the possibility of the unauthorized closure of automatic sprinkler system shut-off valves is the only remaining nightmare before the eyes of fire protection experts. In view of the record of fire losses due to such unauthorized or accidental shutting off of the water supply to sprinkler systems, it is singular that so little has been done to give any *automatic* protection against such a possibility. All the rest of the apparatus, such as the sprinkler head, the alarm valve, the dry pipe valve, and the system of sprinkler piping, has been developed to a high pitch of perfection; but this one point remains to be developed.

Impressed with the importance of this problem, I have invented and developed a simple and inexpensive piece of mechanical and electrical apparatus designed to supplement the very suggestions contained in Mr. Miller's paper. Mr. Miller desires the master mechanic, or the person in charge of the sprinkler systems in an establishment, to divide a printed card in the middle, fill out on each half the reason for closing the shut-off valve and the time when it may be expected to be opened and the pressure restored to the system again, and then requires him to tie one-half of the broken card to the stem of the gate valve and to carry the other half into the office and leave it with some authorized person who shall share with him the responsibility for shutting off the water supply.

This system would be, of course, entirely satisfactory provided the person who is required to carry it out really does so. It does not take very much imagination, however, to suggest many everyday reasons why it would be for the interests of such a person to omit such notice altogether, in which event there is a large possibility that the valve may be left shut, whether intentionally or inadvertently, for a long period of time. For example, a workman may go home to luncheon at noon leaving the valve shut, and something may interfere with his return; if the job is to be done at night, or the job of repairing the sprinkler system extends into the evening, the person notified by the other half of the card may be absent until the next day, in which case it might easily be that the valve would be left shut at least until his return.

The device which I have developed makes it *necessary* for the master mechanic to attach his card directly to an electric switch that controls an electric bell, which switch must be opened before he can attach it, and cannot be left open without the aid of a second person. This second person should be the one relied upon to see that the valve is actually reopened at the appointed time. He is also the one who would pay attention in case the valve was shut by some unauthorized person who had not first gone through the process of notifying the man in the office, and getting his assistance in holding the switch open, as this would result in turning in an alarm directly in the office. The way this is effected is by attaching an electric circuit closer to the valve stem of the main shut-off valve in a way such that any motion of the valve stem in the direction of shutting the valve will immediately cause the circuit closer to close the

electric circuit through the alarm bell and the red light in the office.

When the switch is opened through an arc of 180 deg. it will be held open provided the master mechanic has caused the circuit closer on the valve stem to close by shutting the valve; but this would result in an alarm in the office if the assistance of the man who is to be notified that the valve is to be shut has not actually been obtained to hold the controlling switch clear open against an electric magnet energized by the same current that lights the light and rings the bell, while the other man goes to the sprinkler riser and shuts the valve.

It will be observed that this mechanical and electric supervisory system is entirely supplementary to the system proposed by Mr. Miller, that it does not interfere with it in the slightest degree, and that its influence is positive if it actually works as intended, but that if it should fail to work there would be no interference with the operation of the simple card scheme. This system has been in operation in my own factory for several months, has been demonstrated to various underwriters, and seems to be quite satisfactory. No doubt about its operation, either theoretically or actually, has thus far developed.

The principle covering the development of this device is that more than one man should have something to say about the opening and shutting of sprinkler valves, and that the operations of the extra person should be mechanically interlocked with those of the person directly charged with the oversight of the sprinkler system. The device in question, in addition to being supervisory over the motions of the shut-off valves, is also a fire alarm and a water pressure alarm. In regard to the latter point, it may be said that the bell will ring and the light will light if the water pressure falls beyond a certain predetermined point.

In the history of sprinkler systems it has frequently happened that main shut-off valves have been shut with a heavy hand and then *apparently* open again, when, in reality, it was subsequently found out that the only part of the valve which opened was the stem, which had become detached from the plug. This may easily happen when the valve stem is shut with a big wrench in an outside gate and the stem is twisted after the valve has bedded upon its seats. In such a case as that, my alarm system would call the fact to the attention of the office automatically.

James P. Tolman. It appears to me that Mr. Miller's instruction tag does not afford all the protection that is possible. In our mill we have used a tag similar in style to that, but in place of the circular hole we have a slotted hole, through which is passed a piece of lace leather. The leather is also passed through the yoke and the arm of the hand wheel, which seals the valve. The lace leather is secured by a tubular rivet, easily applied. Each valve which controls sprinklers throughout the mill is always sealed, either open or shut. If it is a valve which should be closed in winter, it is sealed shut. If it is a valve which should be open at all times, it is always sealed open, and the tag requires any person breaking the seal to take the tag to the office. Recently the Mutual Insurance Companies have been sending out the tag shown in the latter part of the paper, and we felt that it was an improvement and adopted it. But we also retain our old form of tag, which we now make from green card, and this green tag is on every normally conditioned valve at all times, showing that the valve is sealed, and that persons who break the seal of the valve are to take the tag immediately to the office. If a valve has its seal broken, there is a notice. The red tag has supplanted the green tag, and every valve should always have one or the other tag upon it.

One of the objections made by Mr. Rockwood to the tag is that when a valve was marked with a red tag, it would never be seen by anybody unless he *happened* to see it. I want to say that it is the practice of all the mutually insured mills to have weekly inspections of the fire protective system. We have different men inspect the system for different periods of time. If a valve is wrongly marked, having the red tag instead of a green tag, it will be brought to the attention of the superintendent at least as soon as Monday morning.

Gorham Dana.[1] I agree with the previous speakers that the matter of a closed valve in the sprinkler system is a most vital point in the matter of fire protection in sprinkler-equipped plants. If we could eliminate the unnecessarily closed valve, the fire loss would be very materially reduced.

The scheme which one of the speakers proposed is an admirable one for certain conditions, but it does not seem to cover our conditions. In order to succeed with such a plan, it is necessary that a plant should be extremely well managed, with an efficient master mechanic and an efficient superintendent. There are a good many plants equipped with automatic sprinklers that do not have these conditions, a great many tenant factories, and a great many New York loft buildings, where there are many different firms in the building, and where it is difficult to get at any one to care for the sprinkler system. There are a great many small plants in various towns and cities that have no master mechanic who is worthy of the name, where the problem is very different.

The organization with which I am connected has been working on this problem for a number of years, and we have solved it in rather a different manner, which, to my mind, covers cases which this scheme would not cover. The plan is to have the valve fastened by the insurance inspectors. The tag which is used is slipped over the seal and is used in case the seal is broken to notify the insurance company. That is to say, the tag is similar to the one shown here, but somewhat differently worded, and in case the seal has to be broken to close the valve, the person who breaks the seal fills out certain data as to the circumstances (the reason for closing the valve, etc., the present condition of the valve, whether it was opened at once or not) and this information is put on the back of the tag and the tag mailed to the insurance inspection department. We find it to be extremely necessary in any plant which has not an efficient management, to have this information sent to the insurance interests.

Mr. Rockwood's scheme is a very excellent one, and I trust it will come into general use, but it has, however, one drawback: if a valve is closed for any length of time the alarm does not do much good. If a valve is closed for repairs, for an hour or two hours, you have got to shut off the alarm and cannot have it ringing all the time, and for that reason some notification to the people most vitally

[1] Manager, The Underwriters' Bureau of New England, 141 Milk Street, Boston, Mass.

interested, the insurance companies, is most desirable in my opinion.

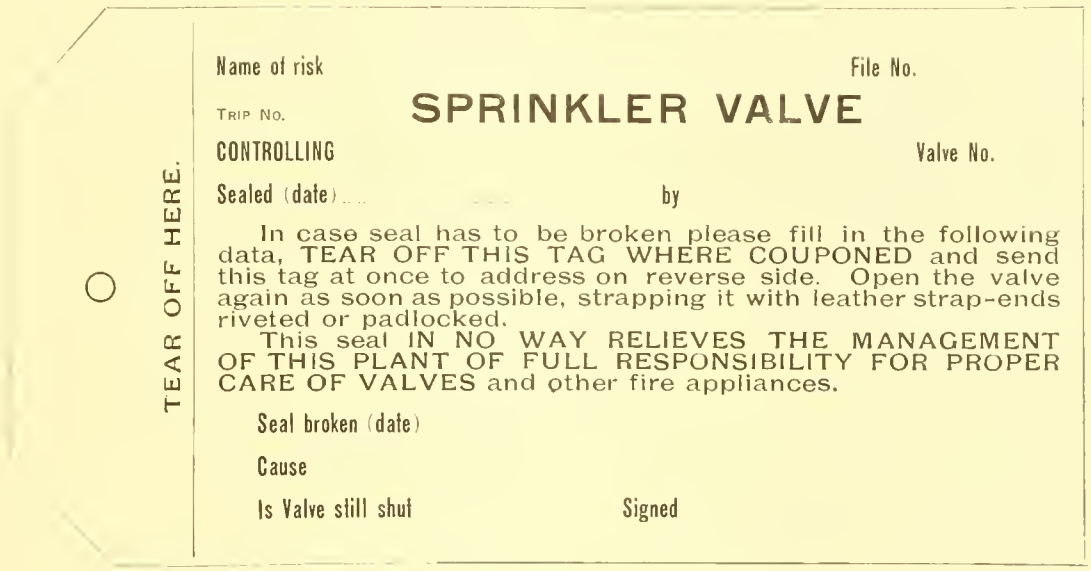
W. H. Kenerson (written). There can be no difference of opinion in regard to the necessity for keeping all sprinkler valves open, and if it is impossible to provide some of the mechanical supervisory devices, the scheme outlined in the paper is highly desirable. I take it that the purpose of the paper is to put before the public a scheme which anybody can employ, and the description of the system is in such detail that I beg to suggest one further simple expedient which will make it more effective. The majority of us have probably had difficulty, when using a system employing tags hanging on open hooks, in keeping the tags in place because of drafts, careless handling, etc. The simple expedient of turning the hooks upside down, will almost entirely obviate the difficulty. Such an arrangement would make this system much more reliable.

Charles H. Bigelow. While I believe the tag is a good thing, exceptional discipline is required to keep it up in every case, especially in places having only a small mechanical force of the class often employed, and where the office is a long distance from the valves. There the tendency would be, especially for a short job, for the man to shut off the valve and do the work, instead of taking the tag to the office, returning to do the work and then going back to the office after the tag, particularly as many of them regard such regulations as "red tape" if they think of them at all. The trouble is, however, that while the men may open up the valve in most cases, there is always the chance of the man being called away and forgetting to open the valve, so that probably the tag system, even if not kept up the way it should be, would be a help.

Pomeroy W. Power (written). The weekly inspection seems to be a very good system to use in connection with any method of keeping track of sprinkler valves. Our plan is giving good results. Every Thursday an inspector examines each indicator post gate and signs a tag, which is attached to the post, with his name and the date. After his examination of all sprinkler valves, the inspector signs a typewritten form of letter, which reads something like this: "I have this day inspected all of the sprinkler valves. They are all open and in good order, except——" Under the list of exemptions he fills in the location of any valve that is closed, the date when it was closed and the date that it is expected to be opened. That letter, after being signed by the inspector, is sent to the manager as a weekly report. After about four years use of this plan, we have had only one case of a valve being found closed.

Lewis H. Kunhardt. This whole question comes down to a matter of responsibility. Some one must be made absolutely responsible in a plant for the maintenance, for instance, of the sprinkler valves, the same as some one must be made responsible for the maintenance of any other piece of apparatus in the plant. A combination of the inspection and the tag will, we believe, fulfill these conditions of keeping the valves open. Of course, there is a fair possibility that something may slip up, but when it does slip up, the point is that you must have some responsible person to whom to look to see why it occurs, and that it does not occur again. Any one who tries this combined plan, that is, a system of inspection and tagging the valves, will accomplish the result.

F. J. Bryant (written). At our plant we have inspection cards giving in itemized detail the route to be followed, showing the location, size, type and duty of each valve, the location of each length of hose, each nozzle, tool, etc., as shown in Table 1. The man making the inspection takes the card and checks each item as he comes to it (if he finds it correct) and notes any discrepancies on the margin. After completing the round he signs the card, as the previous speaker said, and places it upon the manager's desk, who countersigns it and has it filled for further reference.


TEAR OFF HERE.

Name of risk File No.

Trip No. SPRINKLER VALVE

CONTROLLING Valve No.

Sealed (date) by

In case seal has to be broken please fill in the following data, TEAR OFF THIS TAG WHERE COUPONED and send this tag at once to address on reverse side. Open the valve again as soon as possible, strapping it with leather strap-ends riveted or padlocked.

This seal IN NO WAY RELIEVES THE MANAGEMENT OF THIS PLANT OF FULL RESPONSIBILITY FOR PROPER CARE OF VALVES and other fire appliances.

Seal broken (date)

Cause

Is Valve still shut Signed

Fig. 5 Form of Report Tag in Use by Underwriters' Bureau of New England

TABLE 1 INSPECTION RECORD OF HOSE HOUSES AND SPRINKLER VALVES

Andrew Mellon Co., Passaic, N. J.

	Location	Sizes In.	State of Valve
1	Third St., gate valve, city connection	6	Open
2	Mill No. 1, napping depart., indicator post	6	Open
3	Mill No. 1, napping department, drip	2	Closed
4	Hose house No. 1, two way hydrant, washers, spanners,	ft. hose nozzle.	Clear
5	Boiler house, sprinkler line	3	Open
6	Boiler house, sprinkler drip	1½	Closed
7	Boiler house, 6 in. gate in line to mill No. 1	6	Open
8	Old Boiler house, drip	2½	Closed
9	Old boiler house, sprinklers under gallery	2	Open
10	Kier room, kier dye and breach room sprinklers	3½	Open
11	Kier room, drip for above	1¼	Closed
12	Old grey room, drip	2	Closed
13	Mill No. 1, second floor sprinklers for tower	1¼	Open
14	Mill No. 1, indicator post (tower entrance)	6	Open
15	Mill No. 1, indicator post (shipping room)	6	Open
16	Drip in shipping room	1¼	Closed
17	Hose house No. 2, one-way hydrant, washers, spanners,	ft. hose nozzle.	Clear
18	Storehouse No. 2, indicator post	6	Open
19	Storehouse No. 2, basement drip	2	Closed
20	Office, indicator post	6	Open
21	Office, drip in pit of 1st toilet	2	Closed
22	6-in. valve in main rear shop	6	Open
23	Storehouse No. 3, basement drip	2	Closed
24	Storehouse No. 3, two-story end, indicator post	6	Open
25	Storehouse No. 3, two-story end, drip	2	Closed
26	Storehouse No. 3, one-story end, indicator post	6	Open
27	Hose house No. 3, two-way hydrant, washers, spanners,	ft. hose nozzle.	Clear
28	Hose house No. 4, two-way hydrant, washers, spanners,	ft. hose nozzle.	Clear
29	Hose house No. 5, two-way hydrant, washers, spanners,	ft. hose nozzle.	Clear
30	Mill No. 2, indicator post	6	Open
31	Mill No. 2, drip	2½	Closed
32	Hose house No. 6, two-way hydrant, Spanners, washers,	ft. hose nozzle.	Clear

The above has been examined by me to-day.

Date, ... Signed.....

Countersigned by.....

THE AUTHOR. Before adopting this system of cards, we carefully considered mechanical and electrical devices for controlling our valves. There are men in our organization who have devoted a great deal of study to electrical devices and they at once thought of like means of controlling valve opening and closing, and proposed several schemes. We have, after careful study of the matter, come to the conclusion that it is better to depend upon our discipline and organization and to have some one responsible for these valves. If we put a mechanical or electrical device on the valves, any one would still be able to close it at will, and it would not involve the doing of anything else. We believed that notwithstanding the use of such a device we would have to go to some form of tag and report in addition. It is a fact that any automatic device, such as a water level indicator in a boiler, or anything of that sort, that is depended upon to indicate danger or abnormal conditions is apt to be depended upon too much; some day it will not work and then there is disaster. For our conditions at any rate, a thoroughly organized system for taking care of these valves and a definite placing of responsibility upon someone for their condition is the best. The seal idea for the card seems to be good, and would be a useful addition to it.

We had, as stated in the paper, before this card system was installed, a very thorough system of inspection for these valves, and we still maintain that inspection system. But the trouble about a weekly inspection is that if the inspector looks at a valve on a Thursday morning, the valve may be closed until the next Thursday morning and no one know anything about it except the man who closed it. Our system provides that someone must know about it; some responsible person must know immediately if the valve is closed, and we think that is important. Of course, there must be discipline, a definite placing of responsibility and strict accountability.

THE NEED OF MORE CARE IN THE DESIGN AND CONSTRUCTION OF ELEVATED TANKS

By W. O. Teague, Boston, Mass.

Member of the Society

The elevated or gravity tank for fire protection systems has been from the first an important limited secondary source of water supply, and its value has increased greatly with the increase in number and size of tanks installed generally throughout the country, especially in those cities and districts where the public water supply is of low pressure, as is the case in Philadelphia. The tanks are usually located above buildings in cities and on detached towers in the country, the 75,000-gal. tank on a 90-ft. tower at the plant of the Pratt Chuck Company, Frankfort, N. Y., as shown in Fig. 1, being a typical detached structure.

The tanks were first made of wood, but there are now as many being made of steel. Wooden tanks have been built up to 100,000 gal. capacity, although they are rarely larger than 60,000 gal., for above this capacity the steel tank is cheaper and more practicable. The cost of a 60,000-gal. tank of wood or steel erected on a 75-ft. steel tower is about $3000. Steel tanks are built in large sizes, one of the largest being of 1,200,000 gal. capacity; this one is 50 ft. in diameter and 90 ft. high, and is supported by a steel tower 130 ft. high.

Failures of tanks in service, involving loss of life and destruction of property, have shown the need of more care in the designing and construction of them. To insure the best results, the following features should have attention.

WOODEN TANKS

The tightness and durability in the wooden tank depends chiefly upon the quality of the lumber and the details of its construction. Selected tank stock only should be used consisting of white cedar, cypress, white pine, Douglas or Washington fir, or redwood, and the

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lumber should be free from sap, loose or unsound knots, worm-holes and shakes, and be thoroughly air-dried. Both the staves and bottom are usually made up of 2½-in. stock dressed both sides, for tanks up to 16 ft. in diameter and 16 ft. deep; for larger tanks 3-in. stock is used. Plank for this purpose should be full length without splices.

The strength of the wooden tank depends principally upon the size and spacing of the iron hoops. The importance of the matter of the hooping will be appreciated when it is realized that overstressing of even one hoop may result in bursting of the tank. The wooden tank being originally merely a development of the barrel where flat hoops were necessary to permit of tightening by driving them toward the enlarged middle, it was natural to use also flat hoops for the tank and the tank was also made tapered so that the hoops could be tightened by driving, although later they were tightened principally by hoop lugs. It was claimed that the tapered shape had also the advantage of preventing the hoops from dropping down over the tank, if it was allowed to remain empty and the staves to shrink from drying.

The tapered shape of tank is not important, however, since a tank which has been allowed to dry up, has been seriously damaged thereby and cannot be made tight without extensive repairs, sometimes necessitating the rebuilding of it. In fact most tanks are now made without taper and the hoops are found to remain where placed. The tapered tank costs somewhat more to build since the staves must be fitted more carefully and the design undoubtedly would have been entirely discarded long ago, except that some architects and purchasers believe a tapered tank presents a more pleasing appearance. The amount of taper is so small, being usually 1 in. per ft., thus giving a batter of ½ in. per ft. to each side of tank, that its absence is hardly noticeable except on very high and small diameter tanks. The only objection to the tapered tank, however, is its extra cost.

In the early studies of this subject, many serious failures of tanks were traced to weakening of the flat hoops by their rusting at the back where they bore against the staves, due to moisture from rain being retained between the surfaces of the hoop and staves. These failures were largely unpreventable, as it was difficult to properly inspect the condition of the hoops, and also impossible to paint them while the tank was in service. The use of hoops of round rod without welds has remedied this trouble as their surface is nearly all exposed for inspection and painting, and also they are not so subject to corrosion since the exposed surface of a round rod is much less than that of a flat bar or band of the same cross sectional area.

Another point of weakness in the flat hoop is at its connection to the cast iron lugs which is usually made by riveting. The use of round rod hoops, however, permits of a satisfactory connection to the lugs, but at first many tank failures resulted from the use of light cast iron lugs. These are now made of malleable iron, the best design being shown in Fig. 2. The hoops are so placed on the tank that the lugs do not come in a vertical line.

Round rod hoops are so spaced that the stress will not exceed 12,500 lb. per sq. in. when computed from area at the root of the thread. The proper spacing can readily be found from the following formula:

$$\text{Spacing of hoops (in.)} = \frac{\text{Safe load for given hoops (lb.)}}{2.6 \times \text{diameter (ft.)} \times \text{depth (ft.)}}$$

The depth used is the distance from overflow to point

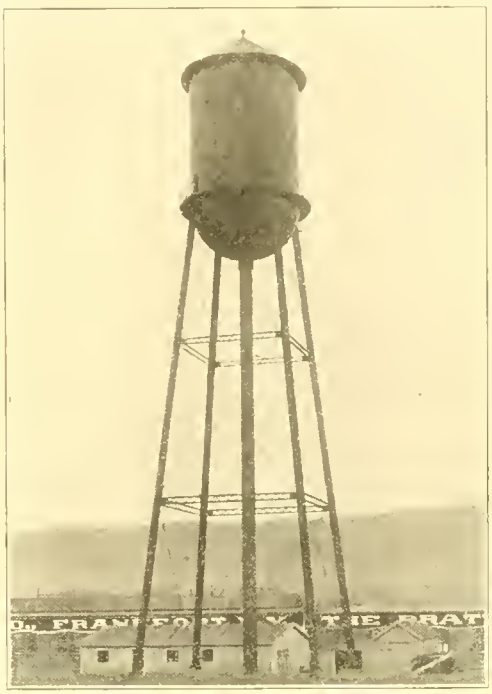

Fig. 1 Typical Detached Tower Structure for Elevated Tanks

where hoop is to be located. The top hoop is placed 2 in. from the top of the staves and the spacing between hoops should in no case exceed 21 in. An extra hoop or two is placed at the croze to take the additional strain due to the swelling of the bottom planks.

The tank roof, since it in no way serves to retain the water, has usually been nothing more than a makeshift cover. In the early days a single flat roof was used on outdoor tanks, but this held the snow and ice and required strong joist supports to keep it tightly in place. The snow also interfered seriously with the opening of the hatch to give access to the interior of the tank. A conical roof was then built over the flat one which remedied these difficulties. It also greatly increases the efficiency of the roof in preventing radiation of heat from the tank water in winter as it provides a dead air space between it and the flat roof in addition to the one between the latter and the

water, thus reducing the cost of heating in freezing weather. The conical roof also gives a better appearance to the tank top. A well built roof is shown in Fig. 3. It should be tightly fitted around the tank top to maintain the dead air spaces.

Much trouble has resulted from leakage in the wooden tank, because it has not been firmly supported. The wooden tank is locally weak, not being of unit construction, and the lack of firm support has permitted working of the joints. It is supported only from the bottom, none of the weight being carried by the staves. Wooden beams were first used as supporting members, and these were placed on the roof of a building or tower as a grillage, and the tank bottom set on them. In time the wood rotted because of moisture from the tank bottom, permitting the tank to settle and

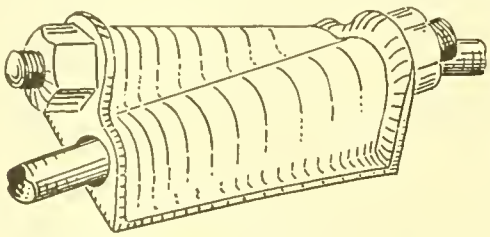

Fig. 2 Preferable Design for End Lugs in Malleable Iron for Round Rod Hoops

causing leakage; there was also danger of collapse of tank because of this weakening of the joists. The use of steel I-beams as grillage members as shown in Fig. 4 avoids these difficulties. The beams should not be spaced over 18 in. clear between edges of flanges, and the tank bottom is placed directly on the steel.

STEEL TANKS

The simplest form of steel tank is the flat bottom one and tanks of this type give satisfactory service, provided the bottom is supported by a steel grillage as in the case of the wooden tank. One possible source of trouble is from corrosion of the bottom, and to prevent this in so far as possible the bottom plates are made somewhat thicker than is necessary for strength alone, and the grillage I-beams are of a height and spacing to permit of inspection and painting of the bottom. When the tank is to be placed on a concrete tower, it may rest directly on a reinforced concrete slab with the bottom thoroughly grouted in place with neat cement.

The preferred form of a tank to be placed on a steel tower is that having a hemispherical or elliptical bottom. The construction in this form is cheaper than for the flat bottomed tank as the bottom is self supporting and a steel grillage is unnecessary. The entire bottom is also accessible for inspection and painting, and corrosion is reduced to a minimum since the plates are exposed to the air.

Plates for use in steel tanks are made somewhat thicker than is necessary for strength in order to make them durable against corrosion. The minimum thickness is $\frac{1}{4}$ in., except that $\frac{1}{8}$-in. plates are used for roofs. The plates composing the lowest cylindrical ring are $\frac{5}{16}$ in. thick for 60,000-gal. tanks and larger, and the bottom plates $\frac{5}{16}$ in. thick for tanks 75,000 gal. and larger.

One of the weaknesses of steel tank construction in the past has been poorly designed connections of the tank shell to the posts of the supporting tower. When the posts have a batter, as is usually the case, the inward thrust due to the horizontal component of the weight is provided for by a circular girder consisting of $\frac{1}{4}$-in. plate 24 in. wide, attached to the lowest cylindrical ring by an angle and stiffened by angles or a channel at the outside edge, as shown in Fig. 5. The posts also connect to the tank shell at this point and the design is such that the load will be transferred from the shell to the center line of the posts so as to avoid eccentric loading. A number of tanks built without circular girders have failed by the posts crushing in the tank plates. Others with the girder, but having eccentrically loaded connections to the posts have failed by bending of the upper posts.

As the hydrostatic pressure on the tanks is comparatively small, it is not necessary to provide standard

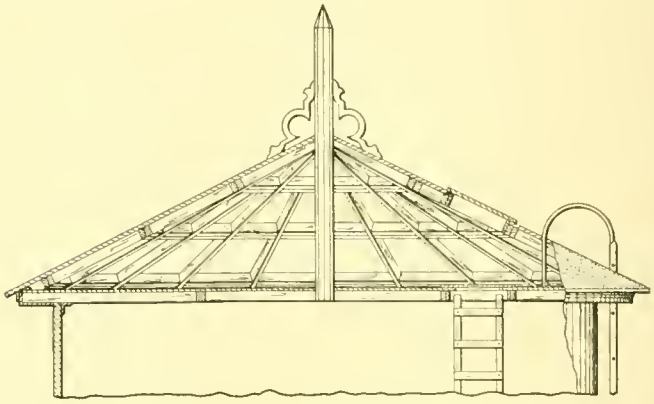

Fig. 3 A Good Design of Double Roof for Elevated Tank

riveting for the thickness of plates used. The joints of the plates should be riveted so that the unit stresses on the net section of the plates and rivets will not exceed 7,500 lb. for shearing and 20,000 lb. for bearing. The horizontal joints are single lap riveted, except between the lowest cylindrical ring and the bottom, which are double lap riveted. The vertical joints also are single lap riveted except those in the lowest cylindrical ring, which are double lap riveted. The rivets are entered from the outside and driven from the inside and inside seams caulked. One of the strong features of the steel tank is that when once made tight, it gives practically no trouble from leakage.

TOWERS FOR ELEVATED TANKS

Towers to support wooden tanks were originally built of wood, but with the increases in size of plant

buildings and extensions of them, considerably larger tanks and higher towers were required, and the builders, realizing the inadequacy of wooden construction under these conditions, began to make towers of steel. The managements not being experienced in structural steel designing, naturally selected the simplest design possible for the towers. The posts and girts consisted usually of two angle irons, placed apex to apex and strapped together at intervals of several feet by tie-plates shop-riveted to the angles. The column sections were spliced by angles which were shop-riveted at one end to the post; the other end was field-bolted in erecting the tower, as this was the simplest form of connection and the easiest one to make. Furthermore, it had the advantage that the bolting could be done by the regular erecters which made it unnecessary to have first-class mechanics in the erecting gangs and to carry special tools. This, however, was not good construction and the manufacturers are now field-riveting these connections.

The struts were at first connected directly to the posts by bolts. This construction is objectionable because the bolts are apt to work loose and it does not brace the parts. The construction now used is that of gusset plates riveted to the posts and girts. The

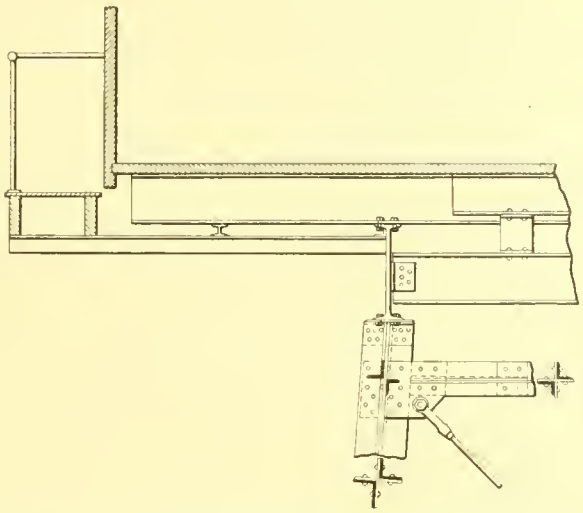

Fig. 4 Detail View of Arrangement of Steel I-Beam Grillage for Support of Tank

wind rods were also connected directly to the posts at the girts. The bolt holes, as originally inserted through the post angles, weakened the posts since they reduced the net section. The rods are now connected to the gusset plates. The arrangement of these parts is shown in Fig. 4. The diameter of bolt and thickness of plate are proportioned to provide proper bearing strength. The posts and girts of steel towers erected to support steel tanks, and to some extent wood tanks, are now largely made of channels latticed on both sides or having a plate on one side. Other shapes such as the Bethlehem H-beam and two channels with an I-beam between to form an H-section are also used to some extent.

Competition in the manufacture of these structures has resulted in the use of too high unit stresses and as a result the posts, figured on a conservative basis as represented in case of their structural work such as bridges, had a factor of safety of less than four and sometimes as low as two and one-half and failure has resulted. To obtain safe towers it became necessary, therefore, to set maximum allowable stresses. The loading of the structure consists of the weight of the structural and ornamental steel work, platforms, roof,

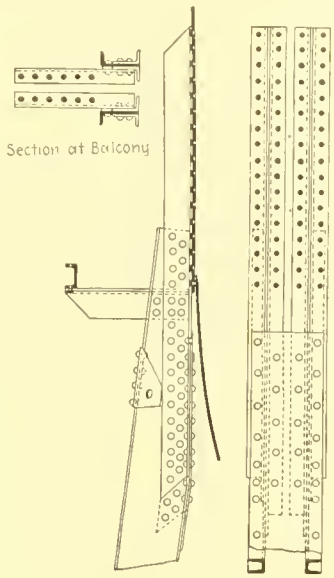

Fig. 5 Detail of Attachment of Tank Shell to Tower Post and Circular Girder Construction

piping, etc. The live load consists of the weight of the total volume of water; the movable load on the platform is assumed to be 30 lb. per sq. ft. and the wind load. The wind pressure is assumed at 30 lb. per sq. ft. on flat vertical surface and the wind load on the tank is taken as this pressure times 6/10 the projected area of tank and roof, and in the case of steel tanks, the curved bottom. The total wind load on the posts, struts, wind rods, ladders and riser boxing is assumed at 200 lb. per linear ft. of height of tower.

All parts of the structure are proportioned so that the sum of the dead and live loads shall not cause the stresses to exceed those allowable. The principal stresses in such a tower structure are axial compression on gross section of columns and struts, axial tension on net section of wind rods, bending on extreme fibres or net section of rolled shapes, built sections and struts, and shearing of rivets. The axial compression on gross section of columns and struts is determined from the following expression: $17{,}100 - 57\,\frac{L}{R}$, where L is the unsupported length of the members from centre to centre of connections in inches, and R the least radius of

gyration in inches; the ratio $\frac{L}{R}$ should not exceed 125 for columns and 150 for struts and minor members and the maximum compression allowable as thus determined is 12,000 lb. per sq. in. The axial tension on net section of wind rods must not exceed 12,500 lb. per sq. in.; the bending on extreme fibres or net section of rolled shapes, built sections and struts 16,000 lb. per sq. in., and the shearing for shop driven rivets, 10,000 lb. per sq. in. and field driven rivets 7500 lb. per sq. in.

The lower ends of the posts have not been as carefully designed as their importance requires. Frequently, in angle iron towers particularly, no special

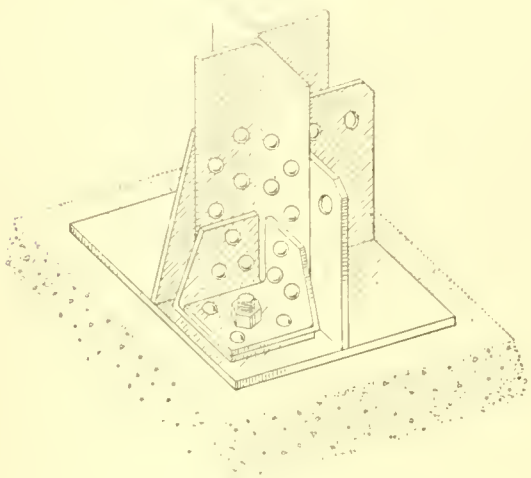

Fig. 6 Typical Construction of Footing for Angle Iron Column

attempt has been made to properly distribute the load to the base plate attached to the post footing. Cast iron plates were first used and the concentrated loading caused these to crack, resulting in collapse or in throwing the structure dangerously out of plumb with possibility of failure of the foundation under this post. The present use of steel plates has improved conditions, but the design must be such as to distribute the load to them as shown in Figs. 6 and 7, which are designs that are being used quite generally.

In anchoring the columns to the foundations, the diameter of the bolt at root of thread should be such as to withstand the maximum uplift due to the wind with tank empty, and to resist the shearing force at base plate. The bolts should be made from round wrought iron or mild steel rods without upsets.

FOUNDATIONS AND SUPPORTS

The foundation piers to support steel towers are usually made of concrete, consisting of one part portland cement, three parts clean sand and five parts broken stone. They are usually pyramidical in shape and proportioned to suit soil conditions. The allowable bearing pressures on soil will range from 1 to 5 tons per sq. ft., depending on the quality of the soil. Where the soil is moist or rather loose, a girt should be provided at the base of the tower to prevent spreading of the posts. The allowable bearing pressures for footings should not exceed 400 lb. per sq. in. for portland cement concrete and 200 lb. per sq. in. for ordinary brick work with portland cement mortar, except when tank is to be rested on building walls, when the bearing plate should be figured on the basis of 125 lb. per sq. in.

The weight of the foundation pier when buried at least two-thirds of its height should be equivalent to the calculated net uplift due to wind pressure with the tank empty, that will be transmitted to it; otherwise it should be one and one-half times that amount.

Where the tank structure is above a building, and the building walls are depended upon to act as supports, great care should be taken to determine that the construction is safe against collapse. In many cases, tanks are supported by building walls not originally built to carry them, but where a sprinkler system was later installed it was considered more convenient and cheaper to use the walls than to erect a detached tower for the tank. This has frequently been done

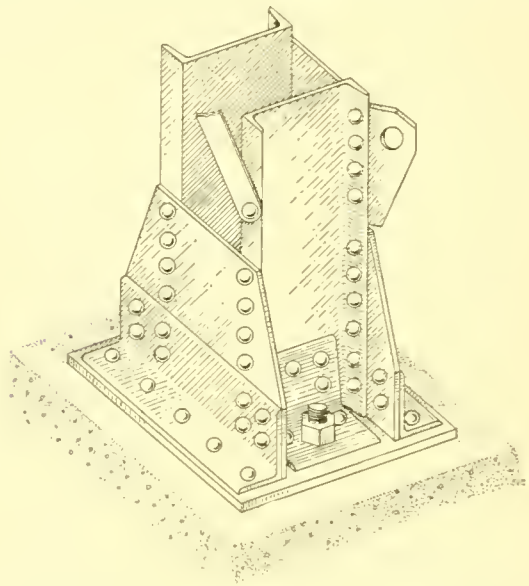

Fig. 7 Typical Construction of Footing for Channel Column

without making a thorough inspection first of the condition of the walls, and, largely through ignorance, the necessary care was not taken to distribute the load. Many failures have consequently resulted and there are no doubt numerous cases of this kind where the tanks are apt to fall at any time.

Inspection should be made of the quality and condition of the brick and mortar or other material used in the construction. The wall foundations should be examined as to construction and bearing on soil or rock. The condition of the bond between abutting walls should be noted and a general inspection made

for sizable cracks in the walls. The thickness of walls and size and spacing of window and door openings should be measured and calculations then made to determine if the load of tank, water and trestle can be safely distributed over the walls. All unnecessary openings should be bricked or otherwise solidly filled in, and it may be necessary to sacrifice some openings to obtain the required strength. When the walls cannot be altered to support the load, the additional support required can be obtained by carrying steel beams down inside the walls to a solid foundation, provided these do not interfere with occupation of or processes carried on in the building. Otherwise it will be necessary to provide a separate steel tower.

The proper strength of foundations is especially important because of the greater probability of loss of life from the falling of a tank from above a building as compared with the falling of a tank on a detached tower. The monetary loss is liable, of course, to be also much greater, as the water will undoubtedly wreck the building and cause heavy water damage. The building departments of cities endeavor to obtain proper construction, but unfortunately they do not always succeed. The possibility of trouble is increased because of the divided responsibility of the tank builder and the architect. The former seldom concerns himself as to the strength of the supporting walls, assuming that the latter has given the matter proper attention, so he goes ahead and erects the tank according to contract.

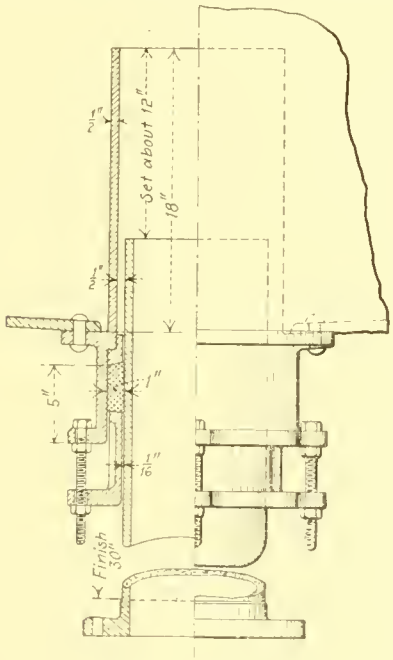

Fig. 8 Example of Proper Design of Expansion Joint for Steel Tank

GENERAL FEATURES

Tank fittings should receive careful attention to insure the reliability of the equipment. The discharge or riser pipe is more serviceable if made up of cast or wrought-iron pipe, flanged or coupled, than one made up of bell and spigot pipe, since the latter is apt to leak at the leaded connections, necessitating removal of the frost-proof boxing to permit of repairs. A tank and tower is constantly swaying from side to side and this tends to loosen up leaded joints. Furthermore, the increased rigidity of the flanged and coupled pipe permits the use of a minimum number of tie rods. There are usually four rods connected, one to each post, at girt connections.

The connection of the discharge or riser pipe to wooden tanks has usually been made by extending the pipe through ordinary cast-iron slip flanges bolted to the tank bottom on each side of the opening. The hole in the planks was cut larger than the size of the pipe to form a packing space which was filled when parts were first assembled. A better construction was used for steel tanks having a stuffing box and gland. Both types of joints were found to be unserviceable, however, the former because the joint could not be tightened when leakage occurred, and the latter principally because the iron to iron parts rusted together, which resulted in the breaking of some pipe fitting and the emptying of the tank. Examples of properly designed expansion joints forming tank connections for wooden and steel tanks are shown in Fig. 8. These have a bronze gland and ample clearance between the iron parts to prevent binding by corrosion. The packing space is large and the joint is extended within the tank bottom to form a settling basin, to prevent sediment getting into the yard pipe and clogging the sprinklers at time of fire.

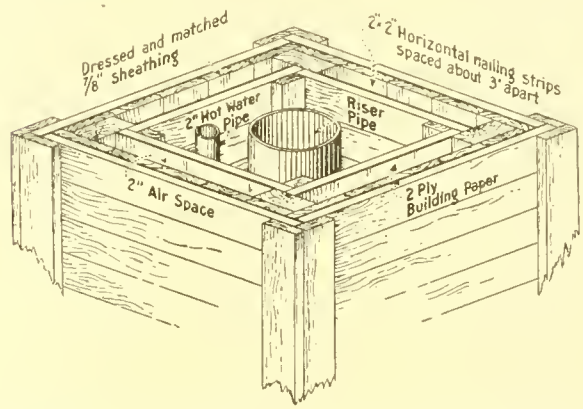

Fig. 9 Design of Efficient Frost-Proof Square Boxing for Enclosure of Riser Pipe to Tank Connection

A tightly constructed frost boxing should be placed around the discharge or riser pipe, and arrangements made for keeping the water heated by a hot water heater or a steam coil in the bottom of the tank. Designs of three-ply, two air-space boxings are shown in Fig. 9.

A tank level indicator or telltale is necessary to give a positive indication that the tank is full at all times. After many serious fires it has been learned that the tank had been partially or wholly empty at the start of the fire, and the lack of water had handicapped

the fire protection devices. Tanks may be left empty due to neglect, but usually so because of false indication of the telltale. The most used type of device for this purpose is the float in the tank water, operating a target sliding on a scale fixed to the outside of tank. Obviously, these are subject to sticking due to their mechanical construction and exposure to snow and ice in freezing weather. The ordinary pressure gage has been largely used but cannot be positively depended on, since it is seldom, if ever, tested and the parts stick,

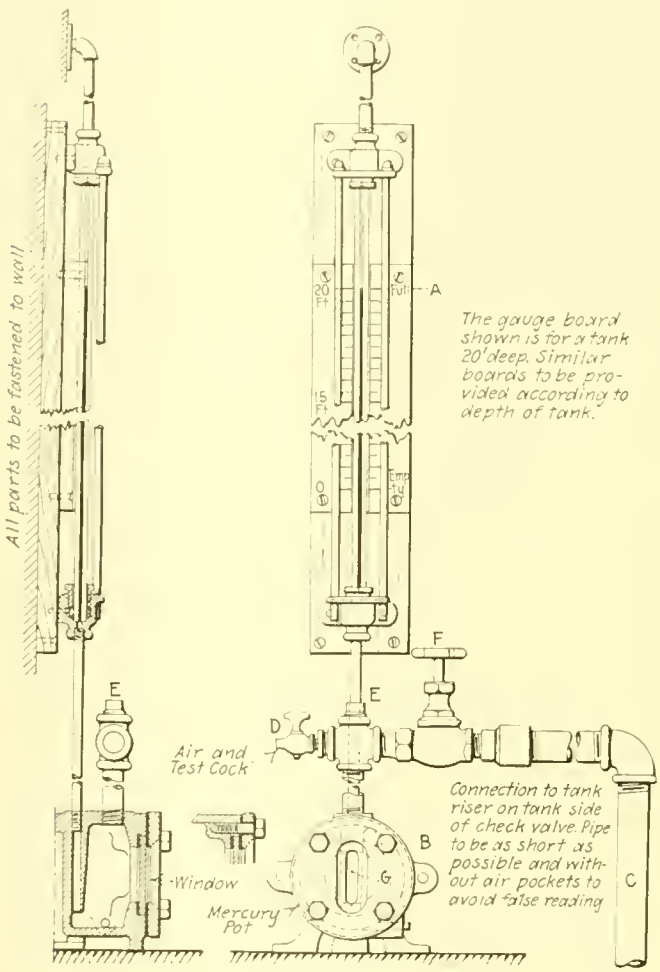

Fig. 10 Details of Mercury Gage for Indicating Water Level in Tank

causing false readings. There are several types of electrical telltales operated by a float, but these are complicated and easily gotten out of adjustment. Attention is also necessary to maintain the electrical current.

The most reliable telltale is undoubtedly the mercury gage, an adaptation of which for this purpose is shown in Fig. 10. This gage was developed by the laboratories of the Associated Factory Mutual Fire Insurance Companies. It should be placed indoors where it will be observed and cared for. The mercury pot is then piped to the riser pipe on the tank side of the check valve, and the gage board adjusted after filling the mercury pot. The gage is readily tested by opening the pet cock on the water pipe. If water continues to flow under constant pressure, the apparatus is in operative condition; otherwise, the pipe is clogged or there is a valve closed.

The painting of steel tanks and towers and of the iron hoops of wooden tanks is very important to prevent corrosion. Steel plates and shapes should be given the usual priming coat at the shop. The surface of the metal should be thoroughly cleaned of mill scale, rust and grease and be perfectly dry before applying the paint. A good paint for the first coat is made by mixing 20 lb. of red lead and 10 lb. of zinc oxide with 3 qt. of boiled linseed oil, the red lead and zinc oxide being ground in. This amount of paint will cover about 50 sq. yd. of surface. A second coat should be applied after structure has been erected. For this a more durable oil or asphaltum paint should be used.

The inside of a steel tank should be repainted, usually every two years, or oftener, if the paint shows signs of peeling or wear. The outside of the tank and the tower should be repainted at about five-year intervals. The surface should be carefully cleaned either by sand blast or by steel brushes or scrapers.

The iron hoops of wooden tanks should receive a priming coat as for structural steel and a second coat after assembly. They should be repainted when necessary. The advisability of painting wooden tanks exposed to the weather is an open question, although a large percentage of the tanks are painted. There is no doubt but that paint protects wood under ordinary conditions, but the objection raised to its use on tanks is on the ground that the tank water percolates through the staves and is prevented from evaporating as it is held under the paint and this is likely to set up dry rot in the wood. It is well known, however, that dry rot does not occur when wood is completely immersed but rather when it is in a moist condition in the presence of some heat. This objection is not considered well-founded and as a rule the tanks are undoubtedly preserved by painting.

The life of properly constructed equipments depends largely upon the care and attention given to them by property owners. The tanks should be used only for fire protection. The practice of using a foot or so of water from the top of the tank for mill purposes is objectionable as the tank collects a larger amount of sediment from the water which is constantly being supplied than it does when used for fire service only. This sediment is likely to settle in the sprinkler pipes and either clog them completely, or, if the sprinklers are open, seriously interfere with their discharge. If water is drawn from the bottom for mill purposes the tank may be empty when needed for fire service. Furthermore, the fluctuation in water level is apt to result in shrinkage of the upper ends of the staves of wooden tanks, causing leakage and hastening corrosion in the steel tank by the repeated wetting and exposure of the sides to the air.

DISCUSSION

J. W. Ketler[1] (written). Improperly designed supports for tank structures on buildings and the sub-foundations are likely to endanger life and property. As an engineer making a specialty of this work I come in contact with faulty designs, principally in the building itself. The fault does not lie entirely with the structural engineer, but in a great many cases with the architect. I would suggest stringent rules governing the installation of these outfits, especially the thorough examination of the building by a competent engineer or architect familiar with this class of work. I would also suggest, and would cooperate to further the acceptance of one uniform set of specifications governing the engineering manufacture and erection of towers and tanks, both on the ground and on buildings, by all insurance companies, and so far as possible by individuals, corporations or city building departments.

B. A. Freeman[2] (written). Lack of uniformity in the design of tanks and towers at present is well known to those interested in that line of work. Besides the cause suggested, close competition, the lack of ability on the part of most purchasers to discern the merits and demerits of designs submitted helps not a little towards that end. There is little novel or unusual in the construction of these structures. All of the problems connected with them have been solved before in connection with other engineering works. Now that elevated tanks and towers have come into general use for fire protection purposes, it is advisable both to protect the purchaser and the bidder who wishes to erect a good structure, that a specification be forthcoming which shall place all competitors on the same basis. A worthy attempt in that direction has been recently made by the engineering department of the Associated Factory Mutual Fire Insurance Company of Boston, and intelligent inspections in connection with such a specification should produce very good results.

Bryan Blackburn[3] (written). Too much credit can not be given to Mr. Teague and his associates for the splendid service rendered along the line of tank betterment. The specifications issued by his office, if honestly carried out, will afford a high-class structure that is simple in design, economical in construction and very efficient in service. I have designed a vast number of elevated tanks for fire protection, and I can say without fear of contradiction that the tanks built under the requirements of Mr. Teague's office are beyond criticism.

I differ with Mr. Teague, however, in that it is allowable to single-rivet the vertical seams above the first course. As pointed out in my article on this subject in The Engineering Magazine,[4] the vertical seams should be double riveted, not so much for strength of joint, as to prevent the breaking of the caulking edge by breathing tendency of shell due to change in water level; also it is my opinion, based on experience, that the riveting should be closer than is theoretically required for efficiency of joint, in order to ensure that the plates be well drawn together under field riveting. The joints in the main column at strut points should be milled to ensure full bearing.

The formulae and stresses set forth in the paper for main members are correct and ample, but I would suggest that, while the struts should be of such section as to provide for all live and dead loads, and that the depth of strut should be such that the unit stress due to weight of member should not exceed 4000 lb. per sq. in., still my experience indicates that more often the sizes of these struts are fixed by the requirement that no strut shall exceed 150 radii of gyration in length.

In the using of the Bethlehem H column for main columns, as suggested by Mr. Teague, care should be exercised to see that the column lengths do not exceed 125 radii of gyration. The standard practice in these elevated tanks allows very long column lengths in the latticed channels columns and this has led some inexperienced designers to employ H shapes in too long lengths, with results that are not pleasing, and in several cases that have come under my observation, partial failures have resulted, not from any inherent defect of the H sections but from misuse.

Stress must be laid on the fact that the so-called balcony used on hemispherical-bottom steel tanks is not an ornament but a horizontal girder subjected to large loads due to the horizontal component of the stress in the column.

A. H. Hayes (written). It is generally conceded that for all structures on which are dependent the lives of men, or the safety of property from destruction, too much care can not be taken in their design and construction; this is the business of the designing engineer. It is also his duty in this day of efficiency, so to plan his structure that he may use no more material than is necessary to take care of the maximum loading which may occur, with, of course, the proper factor of safety.

In the latter part of the section on towers, the author states that "the total wind pressure on the posts, struts, wind rods, ladders and riser boxing is assumed at 200 lb. per lineal ft. of height of tower." This is taken to mean that for all towers carrying tanks, whether of 10, 20, or 100,000 gal. capacity, the wind pressure must be assumed to be the same. This appears inconsistent, inasmuch as the size and shape of the members will vary with the style of construction, and the loads they are to carry.

The writer has, in several years experience, designed many towers to carry the smaller tanks on which the wind pressure, taken at 30 lb. per sq. ft. of flat surface, did not reach 150 lb. per vertical ft.; also others of larger capacity, where the wind pressure greatly exceeded 200 lb. per vertical ft. This is a small consideration when designing low towers, but with comparatively high towers where the wind stresses at the base of the tower equal or exceed those caused by the weight of tank, tower and water, the difference amounts in some instances to 15 per cent. Therefore, a strict economy of material is not possible.

I wish to present for consideration another point along this line not brought out in the author's paper, but which is embodied in the Specifications for Gravity Tanks and Towers, recently published by the Associated Factory Mutual Fire Insurance Companies, with which specifications, it appears, the author is largely to be credited; that is the practice of assuming that the wind pressure on the tower is the same when acting in the direction of the diagonal of the

[1] Chief Engineer, Wendnagel & Co., Chicago, Ill.
[2] Engineer, The Rusling Company, New York
[3] Assistant Engineer, R. & D. Cole Mfg. Co., Newnan, Ga.
[4] Elevated Tanks for Fire-Protective Service, p. 385

tower as when acting in the plane of the bents. This is not correct when the posts are made up, as with many of the smaller towers, of two angles placed corner to corner forming a star section as illustrated in Fig. 4. Here the wind surface, when the wind is acting in the direction of the diagonal of the tower is $\frac{S}{\sqrt{2}}$. Therefore, the maximum compression stress in the post on the leeward side of the tower, due to wind on the posts, is exactly the same as when the wind is acting in the plane of the bents. The pressure in the struts, wind rods and riser boxing is the same whether the wind acts in one direction or another, and the practice of increasing these stresses by the square root of 2 is correct. But in some towers the wind pressure on the posts is the greater part of the total. Take a case where 50 per cent of the total wind pressure is on the posts; then instead of increasing the total wind stresses by the square root of 2, only 50 per cent should be thus increased.

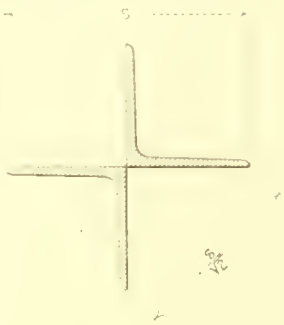

Fig. 11 Surface Exposed to Wind in Post formed of Two Angles

Taking into consideration the fact that an assumption of 200 lb. per vertical ft. in many cases raises the total actual stresses in the posts 15 per cent, and that the latter assumption increases them another 10 per cent, it appears that the author has gone even beyond the limits of conservatism, and in order to meet these requirements the manufacturer is compelled to use considerably more material than is needed. This matter should be left as an incentive to each individual engineer to design his structure so as to present the least possible wind surface, and thus produce an economical design.

A. Blauvelt (written). I take issue to the statement recommending a water level indicator to be placed indoors. Such an indicator is limited to showing the water level in the tank and may not do that because the operator can not be relied upon to use the test cock alluded to, to prove that the connections are clear. As a matter of field service, it is preferable to use a sight overflow pipe placed vertically inside the tank, with the upper end at the desired full elevation of water and the lower end extending through the bottom of the tank and angled over for easy seeing. By such an indicator, much more is accomplished. The operative condition of the means for filling the tank is proved, the operator can not guess that the tank is full enough; he must fill the tank to get an indication, he must look at the tank structure and thereby is more or less compelled to inspect it, and if the heat has failed and the tank frozen, the top of the sight pipe freezes shut and the tank gives warning of ice by overflowing around the top of the tank instead of at the sight pipe.

G. A. Smith[1] (written). The paper is principally an abstract of the author's specifications covering gravity tanks and towers prepared for the Associated Factory Mutual Fire Insurance Companies of Boston. There are a few points in them with which I do not fully agree, but on the whole consider that the specifications cover the field in very good shape. There are two points, however, which I might mention and on which I would like to have the discussion of different members of the Society:

In the section on Towers for Elevated Tanks, Mr. Teague gives a formula for unit stress in water tower columns. This formula gives a unit stress of 12,000 lb. on the basis of 90 radii. It has always been my contention that a higher unit stress is permissible in the design of water tower columns for the reason that the entire load is quiescent and is entirely dead load. There might be some question raised on this point due to the fact that a certain portion of the column load is caused by wind pressure; however, it is the general practice to permit a higher unit stress for wind loads than for either dead or live loads.

It is a general practice of most engineers in the design of steel structures, such as bridges and buildings, to use a higher unit stress for dead loads than for live loads. For instance, Theodore Cooper specifies for bridges a unit stress in chord compression members of 15,000 lb. for dead load and approximately 7000 lb. per sq. in. for live load, both of these stresses being based on 90 radii. On a similar basis, I believe that a unit stress of 15,000 lb. per sq. in. for water tower columns is conservative. I would mention, however, that on account of there being so much sentiment against this high unit stress, the company which I represent has adopted a unit stress of 12,000 lb. per sq. in. for columns in their standard water tower specifications.

Another point on which I do not quite agree with Mr. Teague is the expansion joint illustrated in his paper. The illustration is not quite clear as to the kind of metal used in the different parts, but it is his requirement to use cast iron in the pipe sleeve and the collar, and brass or bronze in the follower and adjustment bolts. I contend that this expansion joint will not permit proper operation after it has been used for some time. It is my idea that the cast-iron sleeve will corrode or rust more or less above and below the gasket, and in fact will corrode to some extent on the surface covered by the gasket. After this sleeve has become more or less corroded, I believe that it will not slide freely through the gasket, and in fact there is considerable danger that the riser pipe would probably give in some other point before sliding in the expansion joint as intended. I cannot see why the brass follower gland used by Mr. Teague is any better than a cast-iron gland for the reason that the clearance between the sleeve and the follower is sufficient to prevent any serious adhesion by corrosion.

My idea of an expansion joint which would always work freely, would be to have a brass covered sleeve instead of cast iron so that the surface coming in contact with the gasket would not be affected by corrosion and therefore would slide freely through the gasket.

C. S. Pillsbury[2] (written). Mr. Teague has done a great deal to bring about the general adoption of proper methods

[1] Manager, Des Moines Office, Des Moines Bridge & Iron Co., Des Moines, Ia.

[2] Chicago Bridge & Iron Works, Chicago, Ill.

in the design and construction of sprinkler tanks, and his specifications are generally recognized by the manufacturers as fairly representing the best present practice in that class of work. In this paper, he outlines a number of suggestions as to proper unit stresses, plate thicknesses, etc., all of which tend to result in a safe and economical structure. The provisions which probibit bolted connections and reduce the shear on field rivets are especially good.

As Mr. Teague says, it is of great importance to design the details so they will develop the full strength of the main members. To those familiar with railroad bridge shop practice, this statement will seem superfluous, but, as a matter of fact, practically every failure of an elevated tank can be traced to an eccentric top post connection, insufficient provision for the horizontal thrust at the top of the posts, poorly made column splices, or some other oversight due to inexperience. To prevent excessive stresses in the tank shell, the number of posts must be proportioned to the diameter and depth of the tank, and provision must be made to resist the torsional moment due to the curvature of the sides. It is also necessary to provide for a number of severe forces other than gravity and wind loads. This last statement is well emphasized by the illustration of a water tower loaded down with ice due to the continuous overflowing of the tank in cold weather. It is only a carefully designed structure that can undergo such treatment without injury.

Following are stress formulae used by the Chicago Bridge & Iron Works which may be of interest in connection with Mr. Teague's paper:

Tank Sides and Bottom. The stress in pounds per linear inch in the sides of a cylindrical tank is $2.6xHxD$, where D = the diameter of the tank in feet and H = the head of water in feet. The maximum stress in a hemispherical bottom is $1.3xHxD$ and in an elliptical bottom $2.3xHxD$. The last two formulae are closely approximate, H and D being the same as before, except that in this case H should be taken as the total depth of the tank.

Posts. The vertical component of the dead load post stress is equal to the total water and metal load divided by the number of posts. The vertical component of the wind stress equals the following:

3-post tower..... $\frac{M}{0.75\,D}$

4-post tower..... $\frac{M}{1.00\,D}$

6-post tower..... $\frac{M}{1.50\,D}$

8-post tower..... $\frac{M}{2.00\,D}$

where M = moment of wind about panel point at the bottom of the post section considered and D = diagonal of tower at the panel point about which moments are taken.

Rods. There is no dead load stress in the rods. The wind stress equals the following:

3-post tower..... 0.500 (V-V′) Sec. A

4-post tower..... 0.707 (V-V′) Sec. A

6-post tower..... 1.000 (V-V′) Sec. A

8-post tower..... 1.307 (V-V′) Sec. A

where V″ = vertical component of post stress in panel above;

V = vertical component of post stress in same panel as the rod,

and A = angle rod makes with the vertical.

Struts. Except where the batter of the posts changes there is no dead load stress in the struts. The wind stress is approximately the horizontal component of the rod stress in the panel below.

THE AUTHOR. As stated in the paper and as emphasized by Mr. Ketler, the possibility of danger to life and property from elevated tanks is greatest when they are erected above buildings. I fully agree with Mr. Ketler that buildings should be carefully examined by a competent engineer to ensure that they will safely carry the load to be imposed upon them. His suggestion that a standard specification should be adopted by all parties interested is a timely one, as the recently developed specifications of the Associated Factory Mutual Fire Insurance Companies can be used as a basis, such changes or additions being made as seem necessary so that the standard will thoroughly cover all conditions. It would be desirable to have this Society assume the leadership in the work.

Mr. Freeman also advocates uniformity in the design and construction of tanks and towers, and recommends a standard specification following along the lines of those of the Factory Mutual Companies.

In reply to Mr. Blackburn's suggestion that the vertical seams above the first course be double riveted, I have not considered it necessary to advise this, since experience with the single-riveted joints has thus far been quite satisfactory. Certainly if much trouble from leakage at these joints should be experienced, the double riveting would be advisable.

Mr. Hayes has brought up a point which should receive more careful treatment, i.e., the wind load on the tower members and pipe fittings. I have followed current practice in assuming the total wind pressure on these members as 200 lb. per linear foot height of tower and have not, as yet, attempted to vary the pressure to suit various heights and types of towers, although I believe that this is advisable, especially in the case of towers to support tanks for other uses, such as water works supplies. The 200 lb. pressure gives reasonably accurate loadings for sprinkler tank towers, as the height of these is fairly constant within limits. A closer approximation of the loading, even for these towers, would, however, be appreciated by the designing engineer.

The further point which Mr. Hayes mentions, that the actual wind pressure varies according as to whether the wind blows at right angles to plane of the bent or diagonally is, of course, correct, especially for angle-iron towers. As a further refinement in determining the wind load on the structure, it would be well to give this matter consideration.

Mr. Blauvelt's comments regarding the use of the overflow to determine if the tank is full, represent the best practice, and I would say that the use of a mercury gage as a telltale is intended merely as a constant indication of the water level, in place of the unreliable float and target telltale and other devices.

In reply to Mr. Smith, 12,000 lb. per sq. in. is considered a proper maximum allowable unit stress in compression for tank towers by most manufacturers and engineers. This stress is none too conservative, in view of the very special type of the structure where failure of one post member results in immediate and complete collapse. Furthermore, the towers are exposed to the weather, and as they are usually the property of comparatively small companies unfamiliar with the proper care of steel structures, they will not be in-

spected and kept painted as will steel railroad bridges and other structures, and so the steel members should have some additional thickness, in order that they may remain serviceable even after some considerable corrosion has taken place.

I agree with Mr. Smith that a brass or brass covered pipe at the expansion joint is preferable to the iron pipe and believe that this would remove the last possibility of binding through corrosion in the present design. This improvement may be secured in time, but the expansion joint shown is so much better than what has been used that it seemed wise not to add further to its cost at this time, since there undoubtedly would have been serious objections raised by the manufacturers for commercial reasons. The advantage of the brass follower is, of course, its non-corrodibility, which will permit its being moved to tighten the packing even if the iron pipe is corroded, as mentioned by Mr. Smith. The oil lubricant with which the packing is saturated will naturally prevent any appreciable corrosion of the pipe where it bears on it and so permit of movement of the pipe without injury to the packing.

The suggestions made by Mr. Pillsbury are important and the data which he has given regarding stress formulae will undoubtedly be useful.

FIRE PUMPS

By Ezra E. Clark,[1] Boston, Mass.

Non-Member

Broadly speaking, any device by which water can be thrown on a fire is a fire pump. In its simplest form, it is a bucket of water and a man. In the earliest days the bucket was supplemented by huge syringes in the form of a bladder or bellows. Later they were made from brass cylinders and were called "squirts." From these crude appliances were developed the hand and steam fire engine around which cluster the memories of many exciting contests during the last century. These devices, however, are all portable in character, and valuable time is often lost in bringing them to the scene of action. Manufacturing properties, particularly, were often located at such a distance from fire engine stations that prompt service was impossible. The incalculable value of a few gallons of water at the beginning of a fire became self-evident, so that pumps fixed upon the premises, connected to a water supply and a source of power, were introduced. Later these were connected to a system of piping about the yard and in the mill, and the pump then became available to supply sprinkler heads, or furnish fire streams from hydrants.

In this paper, the term fire pump is to be used in its restricted sense, i. e., a pump that is installed in a fixed position for fire purposes. In this sense there are three or four distinct types, generally acknowledged; rotary, duplex, centrifugal, and power pumps, any one of which, of course, could serve as a fire engine by mounting it on wheels and providing a source of power.

The type of pump to be selected should be determined by the character of power available for the purpose. Naturally the most reliable source of power at any situation would be chosen, and then a pump selected that can best be driven with that power. This should be the general rule. Every type of pump, however, has its own limitations and these must be kept in mind when studying the whole problem. The natural selection would be a pump that can run at or near the speed of the prime mover. One instance has been noted where a centrifugal pump was connected to a water-

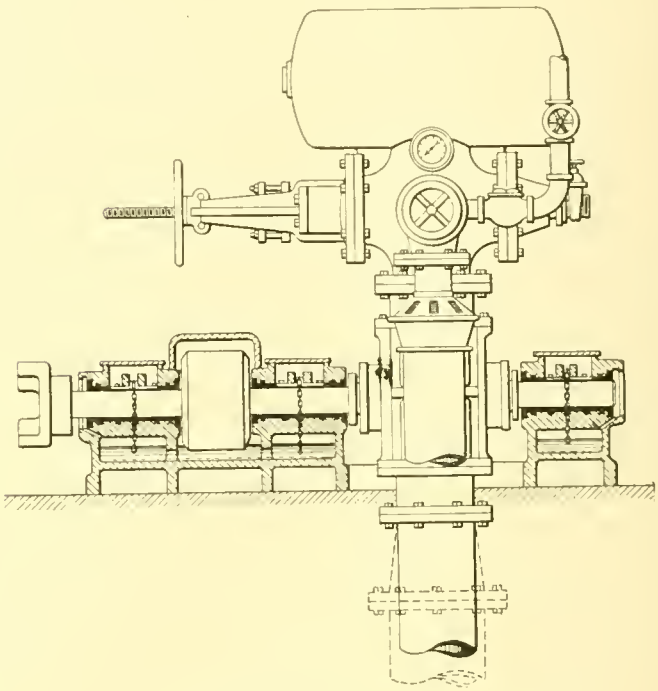

Fig. 1 Part Section of Rotary Pump, Type *B*

wheel through a pair of spur gears having a ratio of 5 to 1, and another case where an electric motor was connected to a rotary pump through spur gearing having a ratio of 1 to 5. In each case, the pumps took their suction supply under a head. Both cases may be dismissed as examples of poor engineering, for the requirements of fire service would have been much better served if the two pumps were to exchange places and the reduction gears omitted, thus securing the simplest, cheapest and most reliable arrangement.

The earlier mills were operated almost exclusively by waterwheels and their usual speed made it comparatively easy to connect with rotary pumps. Thus, a great many pumps of this type found their way into the wheel pits of mills, although they were too often, unfortunately, poorly located. Power plunger pumps were used in a few cases, but the rotary came to be

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Abstract of Paper. Presented at the Annual Meeting, 1913, of The American Society of Mechanical Engineers. Pamphlet copies of the complete paper may be obtained: price, 10 cents to members, 20 cents to non-members.

the prevailing pump, owing to its simplicity, cheapness and adaptability to the prevailing power. Where waterwheels of ample power and moderate speed are available, the rotary type of pump becomes the logical choice, for the two can often be direct-connected, or some simple form of transmission, such as friction gears, or a silent chain having a low speed ratio can be employed. The impulse form of waterwheel with its high speed would find a better selection in the centrifu-

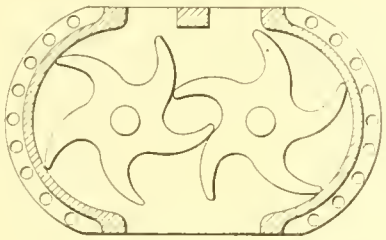


Fig. 2 Working Cams of Rotary Pump, Type *B*

gal pump, requiring no intermediate gearing. In weighing the claims of the several pumps for a situation, three things should be kept in mind: the character of the power available, the limitations of the pump and the fact that the simplest drive is the best.

ROTARY PUMPS

There are so many indifferent rotary pumps in mills and factories that the mere mention of a rotary raises doubts as to its value for fire purposes. Still, it should be remembered that even with the imperfect construction of the old time cast-iron rotary, they have given

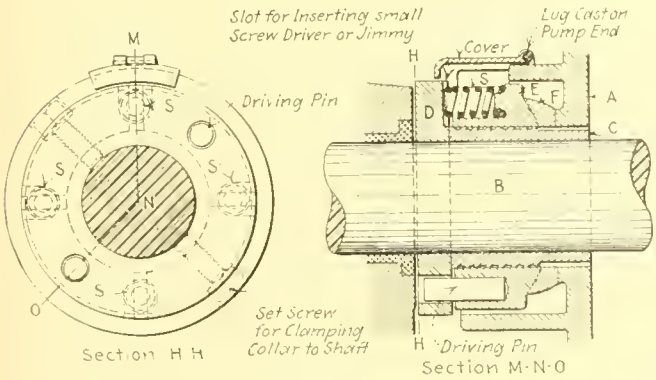


Fig. 3 Water Joint used on Rotary Pump Shafts, Type *B*, as Substitute for Stuffing Box

some very effective service at critical times. However, I invite your attention to that product of the rotary pump builder that meets the present insurance specifications and notably that which is designated as Type *B* (Figs. 1 and 2).

Several features of this design were proposed and developed by the author in 1904. They were not immediately adopted, as some experimental work was necessary, and new patterns were required. These new features were chiefly as follows: In place of the usual two sets of overhung cast-iron gears, one extra-heavy pair of cut steel gears is substituted, preferably forged solid with their shafts; these gears are supported on either side by generous bearings, and the two shafts are larger and stiffer; all bearings are provided with liberal oil reservoirs and ring or chain oilers; in place of the usual stuffing boxes, a special form of metal water joint has been adopted, which is giving excellent service, thereby avoiding the use of perishable packing. The usual fire pump features are also provided; viz., the casing and working parts exposed to corrosion are of bronze; there are more liberal water passages; the working cams are of a new design to insure reasonably smooth running; and the usual air chamber, hose connections, an approved spring relief valve and starting valve complete the arrangement. The press frame carrying the friction gear is now fitted with a heavy spring that maintains the gears in contact, and com-

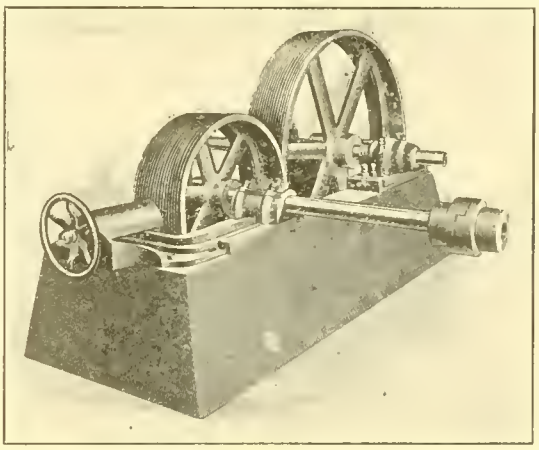


Fig. 4 Typical Press Frame for Friction Gears driving Rotary Pumps

pensates for a possible lack of truth in their running (Fig. 4).

These pumps are not intended for daily service as the wear between cams and casing would soon render them inefficient. But for the brief periods of fire service, considerations of wear are of less importance than certainty of action. Full particulars as to their construction can best be gathered by a study of published specifications. The effort has been to secure a rugged, reliable pump capable of doing hard work, resisting corrosion and withstanding abuse. These pumps are obtainable today from at least two manufacturers, and cost somewhat less than a duplex pump. The limited number that are already in the field are so far giving excellent satisfaction.

DUPLEX PUMPS

Where steam is the most reliable source of power, the duplex Underwriter pump is usually the choice, because of its record of proved value. It is also much the cheapest of any steam-driven fire pump of accept-

able reliability, selling for approximately ten cents a pound. In spite of its numerous parts, liable to derangement, this pump has been so thoroughly boiled down, so to speak, that with present day construction it is proving to be one of the most reliable of fire protection appliances. The steam-turbine driven centrifugal pump is, of course, available for those who are willing to pay the price, but it costs approximately

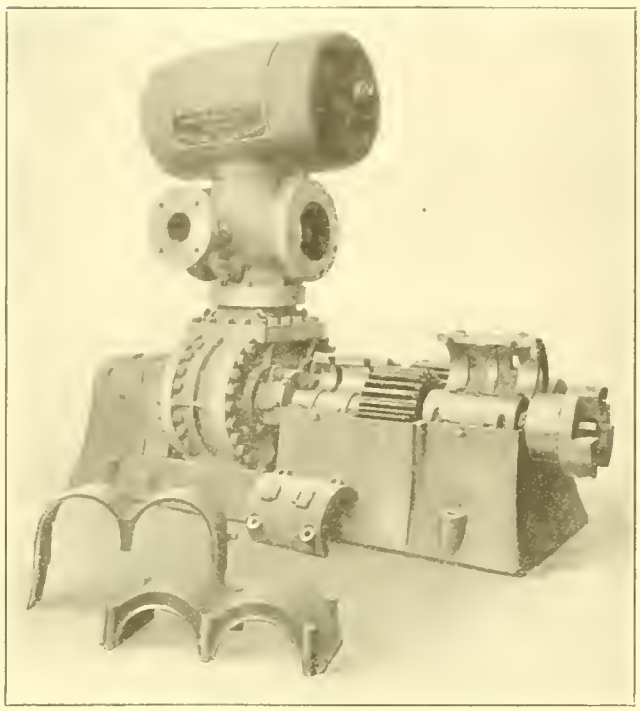


Fig. 5 Rotary Pump, Type *B*, Partly Dismantled

twice as much. Its main advantage over the duplex is its simplicity of working parts. Its disadvantages lie in the fact that a pressure of 100 to 125 lb. of steam is required for good results, whereas, with a duplex pump, 50 lb. of steam is ample for ordinary fire pressures. The outfit is also subject to the same limitations as to suction lift as all centrifugal pumps. When the steam turbine centrifugal has become standardized and its price made more nearly competitive with that of the duplex, no doubt it will receive a much wider introduction.

As steam began to supplement and in cases to supplant water power in mills, steam-driven pumps were installed to help out or replace the rotary. At first the single cylinder pump was used, but the advent of the duplex pump marked the beginning of a better machine for fire purposes. The duplex type of fire pump is so well known that it is hardly necessary to describe it, full information as to construction being available in published specifications. When the development of the Underwriter type of duplex pump was undertaken by Mr. John R. Freeman in the early nineties, he found the pump as made for the trade lacking in several features needed for fire protection. The frequent failures in the field showed mainly that improvement was needed. Pump builders did not fully sense the importance of some of the features that were demanded, and more or less opposition was encountered.

The old trade duplex pumps were found with steam and water passages restricted, but these have been enlarged in the Underwriter type, and a higher speed thus made possible. The trade pumps were iron fitted and became rusted through neglect, so that they could not be started; the Underwriter pump is brass fitted wherever corrosion is liable to seize the working parts. In the older pumps, cast-bronze valve stems were used that worked loose or broke off; in the present Underwriter standard, these stems are of rolled bronze and made heavier, and the guard and nut are so secured in place by a lock devised by the author that the parts cannot work loose (see Fig. 7). In the old trade pump it was common practice to provide means of adjustment for the valve motion, and this adjustment sometimes worked loose, or was tampered with, putting the pump in a lame condition; in the Underwriter design, all adjustment has been ruled out and a simpler and more reliable mechanism is now used. Special fire serv-

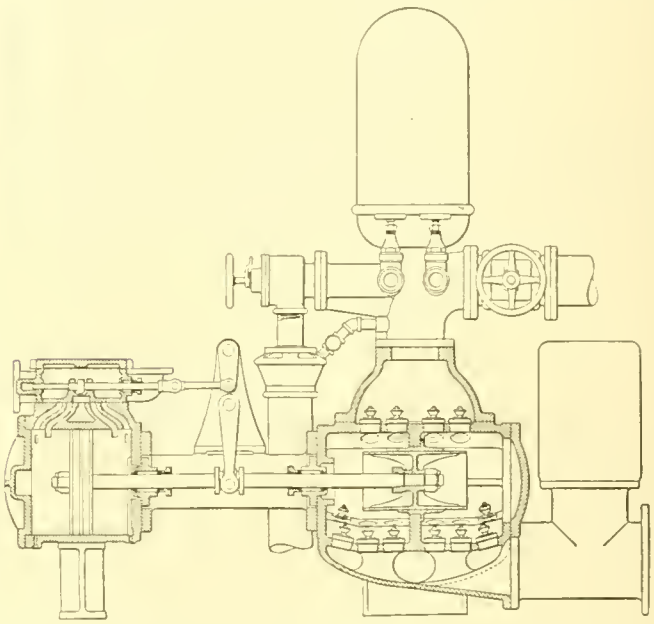


Fig. 6 Sectional View of Underwriter Steam Fire Pump

ice fittings are attached, such as priming valves, starting valve, relief valve, hose valves, oil pump and lubricator, all these parts having been subjected to examination and test before adoption. (See Fig. 6.)

To incorporate these changes has taken time and it has been more or less an up-hill job. Experience, however, has shown the value of these improvements and has indicated from time to time still further improvements which have been adopted, so that today we have a fire pump that is able to start at a moment's notice, run at full speed if needed, and when supplied with steam, water and oil, will run continuously and deliver

its rated capacity, or more, against a fire pressure of 75, 100, 150, or even 200 lb. in special cases.

ELECTRICALLY DRIVEN PUMPS.

Where the electric motor is the most reliable source of power, the centrifugal pump naturally becomes the choice. The speed of a centrifugal pump can readily be made to conform to the speed of the standard motor

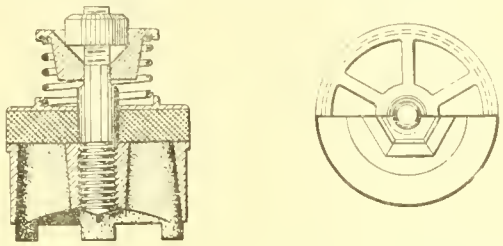


Fig. 7 Detail of Valve Stem and Special Nut Lock

and all intermediate gearing avoided. The direct-connected motor and pump thus form the simplest possible arrangement. It has, however, certain limitations which will be noted later, and there may exist conditions which some form of power pump electrically driven would meet with better satisfaction.

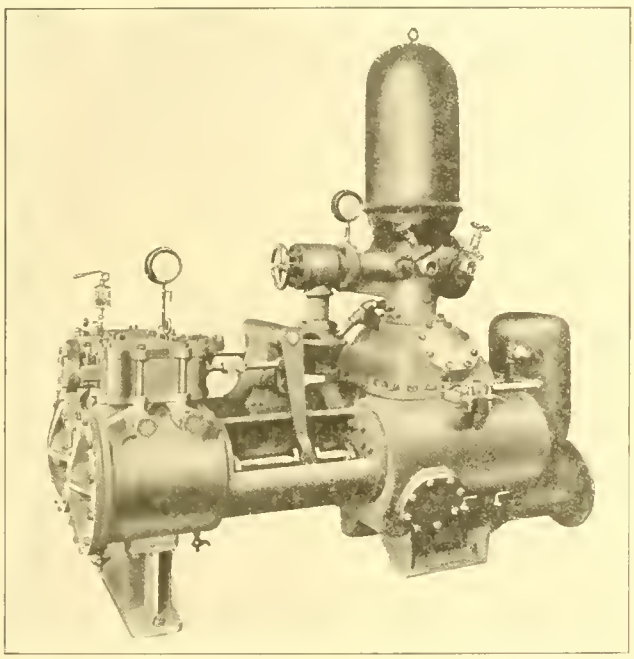


Fig. 8 General View of Underwriter Steam Fire Pump

Comparatively few power pumps are in use as fire pumps, owing to their higher cost. Their best field is where a daily service pump of good efficiency is needed, that can in the emergency be used for fire purposes. The triplex type of power pump is much to be preferred to the single or duplex forms, owing to its steadier discharge pressure, and as it is usually built in the vertical form the floor space required is the minimum. A strong point in favor of the triplex power pump as compared with a centrifugal is its higher efficiency, running as high as 80 to 85 per cent for outside packed plungers as against the usual 65 to 70 per cent for the centrifugal. That type of triplex pump employing one centrally located driving gear is much to be preferred to those having two overhung gears. Experience has shown that the central gear drive will better ensure an even distribution of power, and thus avoid undesirable stresses on gear teeth and possible breakage. A notable example of the central gear triplex power pump may be found in the high-pressure fire service station in Philadelphia, where seven such pumps are operated by gas engines, and

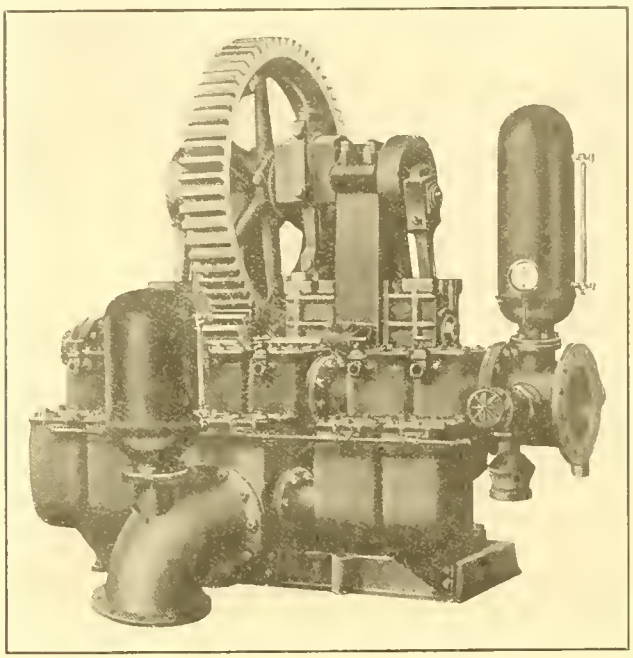


Fig. 9 View of Triplex Power Fire Pump

have given excellent satisfaction with a minimum of repairs.

The centrifugal pump is comparatively a newcomer in the fire pump field. It is distinguished from all others in being a *velocity* pump, the pressure varying directly as the square of the peripheral velocity of the impeller. The electric motor is no doubt responsible for its coming so rapidly into favor. The constant speed motor direct-connected to the pump makes the simplest and cheapest arrangement and affords a fairly wide range of capacities and pressures. The variable speed motor or steam turbine, costing a little more, would place the pump more nearly on a par with the steam duplex as to range of pressures, and, the author believes, would make the preferable outfit. Its greater cost, and complication is the general objection to it.

There are two types of centrifugal fire pumps built, one with the simple cylindrical case, known as the volute pump, and the other with a diffusion vane casing or chute case. The diffusion vane type, sometimes

called the turbine pump, employs a series of gradually enlarging passages that permit a more gradual change of the velocity of the water into pressure than does the volute, thus resulting in some slight gain in efficiency. This, however, is not an essential part of an acceptable fire pump, and as the volute type of pump is much simpler in construction, and yields efficiencies that are satisfactory (60 to 70 per cent), this type of centrifugal fire pump is being generally adopted. This type also lends itself better to the horizontal division of casing, which is preferred to the circumferential division, as it permits quicker and better access to the interior for overhauling or cleaning.

The simplicity of the centrifugal, having but one moving part, appeals to every engineer. There are no valves to choke up, no plunger to wear out, no valve motion or gears to break, and no dangerous pressures possible even with all outlets closed, unless specially provided with a variable-speed prime mover. The discharge is steady, smooth, devoid of shocks, and more nearly approximates that from a gravity supply than any other pump. But it has its limitations, which should be fully realized and considered in making an installation. Unless provision is specially made for a variable speed, its maximum working pressure is usually not planned to be very much above 100 lb. pressure, running for the smaller flows in some cases up to 130 or 140 lb. Consequently the water pressure needs of a situation should be carefully studied before deciding on this form of pumping outfit, and if higher pressures are needed, either a special form of impeller should be substituted or a variable speed provided.

A centrifugal has no power to exhaust the air from a suction pipe, as has the rotary, duplex, or other displacement pump. For this reason, the suction supply should come to the pump under enough head to flood the pump casing, thus insuring its being primed. If a lift is unavoidable, then it becomes necessary to provide a suitable foot valve and a generous supply of priming water, enough to fill completely the suction pipe and pump casing. This feature, of course, limits the centrifugal to situations where there are easy suction supply conditions.

In cost the centrifugal pump with bedplate is but little more than the duplex per pound, but the addition of driving motor brings up the price very materially, so that the outfit combined costs 15 to 16 cents per lb., and weighs about the same as a duplex pump. For a given type, the speed of a motor determines its size and influences the total price of outfit. It may roughly be stated that the centrifugal pump and motor costs 50 per cent more than the duplex. There is a wide difference, however, in the weights of the same size pump among different manufacturers.

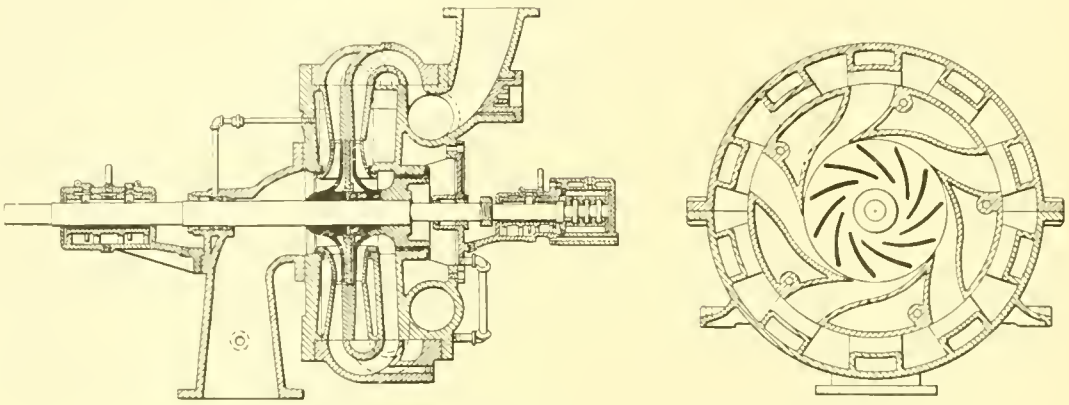


Fig. 10 Centrifugal Fire Pump with Diffusion Vanes

INSTALLATION

The success or failure of a fire pump depends very much on its being properly erected and connected up. Briefly, it may be said that a fire pump must be so located as to be safe at all times from the breakage of its pipe connections due to the falling of floors and machinery, and safeguarded from any influence such as smoke, fire or flood that might drive away the operator. It should be accessible at all times for operating and overhauling, and not blockaded by miscellaneous storage. It must permit of practicable pipe connections, the suction pipe receiving first consideration, and the steam and discharge pipes so run as to be safe from damage and always be in commission. The exhaust should go direct to atmosphere, and not be tied up with other pipes.

The suction supply should preferably be practically inexhaustible, such as a river or lake, and a suitable intake, properly screened, provided. Where a stored supply only is available, it should be large enough to supply the pump for two hours, more or less, depending on conditions. No cast-iron rules can well be established as the insurance engineer having jurisdiction is expected to weigh conditions, and secure a reliable pump service without expensive or complicated refinements. Full details as to pump installation have been covered in the several publications and specifications

which from time to time have been developed in the Factory Mutual Inspection Department.

It will perhaps be of interest, and not altogether without value, to look a bit into the future and try to discern what is to be the development of the fire pump. It is not at all unlikely that the steam turbine centrifugal will gradually displace the duplex pump, as its design becomes simplified and standardized, and its cost lowered. Where steam is not available, we shall find the electric-driven centrifugal, or the gasolene driven rotary, and as fast as its development permits, the gas-turbine driven centrifugal will possibly win recognition and receive adoption. To whatever extent insurance interests adopt these new appliances, it will be done with an eye single to their proved value, as regards simple and rugged construction and reliability of performance.

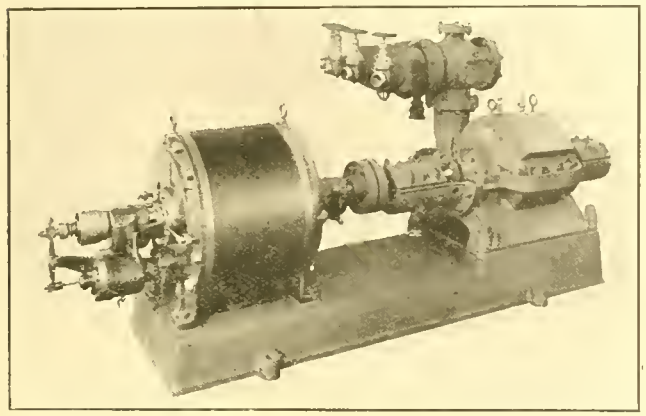


Fig. 11 Example of Steam Turbine Driven Centrifugal Fire Pump Unit

DISCUSSION

Alfred B. Carhart. Upon the practical side of the operation of fire pumps, I think the author of this paper has called attention, in one of the final paragraphs on Installation, to a very important consideration, which was not mentioned in the presentation of the paper. It is such a simple matter, that it seems surprising that engineers in laying out new plants, will connect the exhaust of steam-operated fire pumps with other exhaust lines, and then supply stop valves by which these pipes can be cut off from the exhaust line to prevent back-pressure and condensation, not realizing that when the fire pump is needed in a hurry, it will be impossible to operate it effectively, because there will be no free outlet for the exhaust steam. Such conditions have been discovered, much to the chagrin of those in charge of otherwise admirably constructed plants.

A. Blauvelt (written). Referring to the section of Mr. Clark's paper on electrically driven pumps, it is my observation in the field that the electric motor centrifugal pump is as yet considerably short of working development as compared to the Underwriters steam fire pump. The steam pump is a self-contained affair including the more essential fittings, and ordinarily is handled successfully when needed. The electrically driven pump thus far appears always to require considerably more skill and sense of time on the part of the operator. The motors are excellent and so are the pumps, but neither pump maker nor motor maker appears to know each other, nor do either appear prepared to deliver a complete pumping set, fully fitted and adapted to unfamiliar and incompetent handling in a degree comparable to the steam pump. Meantime, mismoves, or delay or total failure of starting, mark the attempt of watchmen or other men not trained to the electric pump. I take no pride in the various electric pumps installed in our practice thus far, and have less esteem for similar jobs set up under other auspices. Doubtless as the trade increases some shop will put out a complete and self-contained electric pump, with fittings interlocked or timed against mismoves.

The Author. From the remarks of Mr. Blauvelt, it appears that he finds that men not trained to the electric pump make mismoves, or totally fail to start the pump. This is also true of men not trained to steam or rotary pumps.

It should be remembered that the steam fire pump has been growing up with us for 40 or 50 years, and there is a larger number of average men familiar with such apparatus than there is familiar with the electrically driven centrifugal pump. The latter has been with us but a few years, and for the average man it is still somewhat of a novelty that he but vaguely comprehends.

A remedy for this situation does not appear to be getting the pump maker to know better the motor maker. It is rather for the pump operator to know better the apparatus under his charge. It has not been found necessary for rotary pump builders to furnish the waterwheel driving the pump, nor has it been necessary for steam pump makers to go into the steam boiler business.

The troubles arising from centrifugal outfits are mainly due to errors in installation, or a failure to realize the limitations as well as the possibilities of this type of pump.

A properly installed centrifugal and motor is one of the simplest of fire pumps, and easy to start. Regarding interlocking devices to prevent mismoves, these are but complications that add to the confusion of the operator. A simple device under intelligent control is much to be preferred to automatic control involving added complications. It is not necessary for a man to be an electrician in order to operate a motor driven centrifugal, any more than it is necessary for a steam pump operator to be an expert in hydraulics, pneumatics, and the use of steam. But he does need to know something about these matters in either case, and especially to know the use of the fittings and devices that he sees before him. There is no positively certain way to prevent an incompetent man from making the fool move.

There will no doubt be improvements made from time to time based on experience tending to standardize these outfits, which will simplify their operation; but the lack of confidence in present apparatus which is expressed by the gentleman is not shared by the author.

NECROLOGY

GEORGE WESTINGHOUSE

George Westinghouse, Past-President and Honorary Member of the Society, died in New York on March 12, after an illness of several months. He was born at Central Bridge, N. Y., October 6, 1846. A few years later his father, who was a manufacturer of agricultural machinery, moved to Schenectady, where the boy attended the public schools and outside of school hours and during vacations studied mechanics and learned to handle machinery at his father's shop.

When the Civil War came on the patriotic ardor which filled the youth of the country drew young Westinghouse into the volunteer army. Although he was under the age for enlistment, his size and strength were such that he was admitted to the service, first joining the cavalry. In December 1864 he became an assistant engineer in the navy, serving in that capacity until August 1865.

After the war he returned to Schenectady and entered Union College, but this was a classical institution and the bent of young Westinghouse was in the direction of mathematics and engineering. Acting upon the advice of the president of the college, who felt that such latent ability should be given an unrestricted opportunity for growth, he left before graduation and started seriously upon his career in engineering.

Putting the president's advice into practice, he took out his first patent. He had seen a crew of railroad men tediously working to replace a derailed car on the tracks and thought their primitive methods were wasting time. He invented a simple device for the operation and undertook to sell it to the railroads.

On one of his journeys "frog selling," as he has called it, he was close to a collision of trains. The brakemen, tugging at their handbrake wheels, did their best, but the best of handbrakes were primitive affairs, and in emergencies almost useless. He conceived the idea of instantly braking an entire train with some form of power apparatus controlled by the locomotive engineer. In a year or so, after much experiment, he was satisfied that he had made a practical design, but he was without capital to manufacture the equipment of even a single train and to get the invention tried. He went to Pittsburgh, where he obtained encouragement enough to begin in a small way. He patented the air brake in 1867.

The first train to which this brake was applied ran on a line west from Pittsburgh and on what is now a portion of the Pennsylvania Railroad. During the trial trip a collision with a loaded team stuck on a grade crossing was prevented. This practical illustration of the utility of the invention led to the adoption of the brake. Mr. Westinghouse, retaining the control of his invention, undertook to manufacture it and organized the Westinghouse Air Brake Company, establishing at Pittsburgh the business which subsequently became the nucleus of the many industries associated with his name. He later applied compressed air to switching and signalling and utilized electricity in this connection. From this grew the Union Switch and Signal Company.

His introduction of electricity into switch and signal work led him far into electrical experiment and he devoted his energies to a cause in which few then believed, the adoption of the alternating current for lighting and power, in which he had to meet and overcome almost fanatical opposition, which in many states sought legislation against the use of the alternating current as dangerous to the public welfare. In 1885 he acquired the patents of Gaulard & Gibbs, and having undertaken a comprehensive study of the distribution and utilization of electrical currents in a large way, he personally devised apparatus and methods for the work, and gathered around him a group of men who were to become experts in the new electrical art. He also organized the electrical company which bears his name and undertook the development and manufacture of the induction motor which made practical the utilization of the alternating current for power purposes.

The Westinghouse Machine Company was established by Mr. Westinghouse in the 80's for the manufacture of high-speed steam engines, and at this plant has come in succession the construction of large steam engines, gas engines and steam turbines.

Following the discovery of natural gas in the Pittsburgh region, Mr. Westinghouse devised a system for controlling the flow and for conveying the gas over long distances through pipe lines, thus supplying fuel to the homes and factories of Pittsburgh. He took up the study of the gas engine, and for ten years conducted a series of exhaustive experiments in this line, at the end of that time putting into commercial use a gas engine of large power for electric generating.

Mr. Westinghouse introduced the Parsons steam-turbine into this country, adding to it improvements and developments of his own, and others carried out under his supervision. The reduction gearing for driving the propeller shaft of a ship by means of a steam turbine was developed at the Machine company's works, with the coöperation of the late Admiral Melville and John H. Macalpine. Very recently, also, the Westinghouse air spring for motor vehicles was brought out.

It is impracticable to enumerate here the inventions which Mr. Westinghouse had personally made or those which his staff have brought forth under his supervision. As a result of this work and enterprise, there have grown thirty corporations of which he was president at one time, employing 50,000 men, with works at Wilmerding, East Pittsburgh, Swissvale and Trafford City, Pa.; at Hamilton, Canada; London and Manchester, England; Havre, France; Vardo, Italy; and at Vienna and St. Petersburg.

Mr. Westinghouse made many visits to Europe in connection with his inventions and industries. There as in his own country he won the friendship of the foremost men of his time and the high esteem of the engineering profession. He has been decorated by the French Republic and by the sovereigns of Italy and Belgium; and he was the second recipient of the John Fritz Medal "for the invention and development of the air-brake," Lord Kelvin, his friend of many years, having been the first. The Königliche Technische Hochschule of Berlin bestowed upon him the degree of Doctor of Engineering; and his own college, Union, gave him the degree of Ph.D. The Edison Gold Medal was presented to him in 1912 for his "meritorious achievement in connection with the development of the alternating system for light and power." In 1913 the Grashof Medal of the Verein deutscher Ingenieure, the highest honor in the gift of the engineering profession of Germany, was awarded to Mr. Westinghouse on the occasion of the official visit to Germany of the American Society of Mechanical Engineers, and ac-

companying the medal was a certificate which read: "To George Westinghouse, who opened up new fields by his invention of the automatic railway brake, successfully fought for the introduction of the alternating current in the United States, and did useful work in the designing of high speed machinery."

Besides his honorary membership in The American Society of Mechanical Engineers, Mr. Westinghouse was one of the two honorary members of the American Association for the Advancement of Science and an honorary member of the National Electric Light Association. Mr. Westinghouse was two months under 21 when he married Marguerite Erskine Walker, who with a son, George Westinghouse, Jr., survives him. She was his sympathetic and understanding companion throughout his whole career.

MEETINGS

ATLANTA, FEBRUARY 18

A meeting of the affiliated technical societies of the city of Atlanta was held at the Carnegie Library of that city on February 18. The Engineering Association of the South acted as the hosts of the occasion, W. A. Hansell, Jr., President, presiding. Each of the organizations was well represented.

C. E. Kaufman, in charge of bridges and buildings in the department of the chief of construction of the city, and a member of the Engineering Association of the South, presented a paper on The Plaza over the Railroads in Atlanta's Business Center, with a number of explanatory drawings and details of grades, etc. The cost of the scheme was estimated by Mr. Kaufman at $1,714,000.

General discussion was entered into freely by representatives of all of the organizations. Mr. Haralson Bleckley of the American Institute of Architects, the originator of the idea of the plaza, gave a very interesting talk from the artistic standpoint.

BUFFALO, FEBRUARY 26

At a meeting in Buffalo on February 26 in the University Club of that city, an informal dinner preceded the business of the evening. James Hartness, president of the Society, spoke on the Human Factor in Management, upon which he is an authority, dwelling principally on the necessity for recognizing that habit is one of the natural characteristics of one's nature and that we should take advantage of it in any scheme for organization.

He was followed by Calvin W. Rice, Secretary, who spoke of the work of the Society and its extension throughout the country in the local meetings, with the object of serving the members, who should in turn make it their aim to serve the Society and through it the profession. He also spoke of the service which the library is rendering to members at a distance through its staff of searchers and its bibliographies.

BOSTON, MARCH 4

The annual dinner of the engineering societies of Boston was held on March 4, at the Boston City Club, the presidents of the national engineering societies being the guests of honor.

Guy E. Tripp gave the principal address of the evening on the National Government and Business, in which he said he could not attempt in a short address to cover all the points involved in the legislation now before Congress, affecting the operation of public service corporations, and urged every engineer to secure copies of these bills and acquaint himself with their features. He defended American business interests, as involving sane or fair competition.

He was followed by Dr. A. E. Kennelly, vice-president of the American Institute of Electrical Engineers, who spoke on the work of the I.E.C.; and by C. O. Mailloux, president of the American Institute of Electrical Engineers, who emphasized Dr. Kennelly's work in the standardization of the nomenclature of the electrical field.

James Hartness, president of the Society, spoke of the industrial progress in Germany and of the encouragement of legitimate business in America.

The closing address was made by Dr. M. W. Franklin, of the Sprague Works, General Electric Company, on Ozone Applied to Ventilation.

BOSTON, MARCH 11

The March meeting of the Society, held at the Wentworth Institute on South Huntington Avenue, on March 11, was a symposium on welding topics. The purpose of the meeting was to bring out the advantages of welding over other methods of repair, and the possibilities of resorting to such means in place of renewal of parts; also to show to what particular fields of industry or classes of work the several methods of welding may have special adaptation. The various welding methods were individually treated as follows: Oil furnace methods by W. N. Best, consulting engineer on oil furnaces and oil heating, New York; electric welding processes by the Thompson Electric Welding Co., Lynn, Mass.; oxy-acetylene welding, by Henry Cave, president of the Autogenous Welding Co. of Boston, and thermit welding by W. R. Hurlburt of the Goldsmith Thermit Co. of New York. The methods were illustrated by lantern slides and by practical demonstrations.

NEW YORK, MARCH 10

A joint meeting was held by the Society on March 10 with the American Institute of Mining Engineers and the American Electro-Chemical Society, on the subject of Color Photography. There was a large audience and many beautiful slides were shown of colored transparencies made by the several different processes now used in color photography.

The first speaker was Mr. F. E. Ives, whose pioneer work in photography and half-tone engraving is well known. He said that in 1888 he had given demonstrations upon the screen of color transparencies which had created a profound sensation, and in 1889 had prepared colored slides to illustrate lectures on Yellowstone Park, etc., at the Franklin Institute and elsewhere. The public, however, demanded colored prints on paper. He exhibited at this meeting, for the first time, some of the results of new processes of his own which made color photography on paper practical in the hands both of professional and amateur photographers. The first requirement in trichromatic process photography is a camera which will make at one exposure three separate negatives to represent the three primary subtractive colors. He exhibited a camera for this purpose known as the "tripak," about the size of an old style box kodak, which employs a plate pack from which the name of the camera is taken. The pack is used in a single plate holder and handled as a unit

until the negatives are developed and fixed. The three plates are exposed respectively through orange-red, green and violet-blue screens. After developing and fixing, three separate prints are made on a transparent film coated with bichromated gelatine. The exposed film is then developed in hot water, making a gelatine relief print, the three images of which are immersed in their respective dye baths: peacock blue for the negative made with the red light; magenta pink for the negative made with the green light, and yellow for the negative made with the blue light. The transparent prints are then superimposed and cemented together, giving a reproduction of the colors actually existing in the subject photographed.

The Lumiere process was described by Westley Allison. The glass plate to be used is first covered by a mixture of minute starch particles dyed orange-red, green and violet-blue, equally distributed over the surface and filled in with lamp black, after which a coating of panchromatic emulsion is applied. The plate is exposed in the camera with the glass side toward the lens, producing a negative, which is affected according to the amount and quality of light transmitted through the colored grains. The negative is developed, but before fixing is treated with a permanganate of potash solution which converts it into a positive. The varying density of this positive in connection with the colored grains produces the desired colored effects when the plate is held to the light.

C. W. Robinson spoke of the Joly, Macdonough and the Powrie-Warner processes. In all of these processes a screen ruled with parallel red, green and blue lines is interposed between the lens and the sensitized plate; or the screen may be made a part of the plate. The lines on these screens are produced on successive coatings of bichromated emulsion by exposure through a ruled grating and each set of lines is colored by dyeing. In the early Macdonough process, however, the lines were ruled by hand and were made as fine as 300 to the inch, but in the Powrie process the lines were ruled photographically and 3000 lines to the inch are easily obtained. In the Powrie process it is not necessary to adjust the transparency to the screen as in the other ruled or mosaic screen plate processes because the screen can be placed at right angles to the position it was in at the time the plate was exposed and produce good results, on account of the finely ruled lines. He said that Mr. John H. Powrie and Miss Florence M. Warner, both Americans, had worked exclusively on the development of this process for the past eighteen years.

George F. Clifton showed beautiful slides made by the Paget mosaic process. In this as in the Joly, Macdonough or Powrie system, a colored screen is used when exposing the negative, but in the form of a mosaic composed of colored particles, hexagonal in shape, which fit closely together and are more transparent than the starch and lamp black grains of the Lumiere process.

The meeting concluded with remarks by John B. Taylor, Dr. U. S. Kahn and Henry Hess.

Mr. Taylor, who is an amateur photographer, showed a number of slides; Mr. Kahn referred to a new paper called Utocolor, a color paper made abroad, which had lately been introduced in America, permitting the printing of colored pictures directly from a properly exposed autochrome plate; Mr. Hess spoke briefly of his interest in color photography, and especially of his interest in forwarding the work so successfully done by Mr. Ives in producing colored paper prints, and the standardization of the process to bring it within the capacity of the amateur.

CHICAGO, MARCH 18

A banquet was held in Chicago on March 18, at which 225 members and guests were present. Large Steam Power Plants was the subject of the evening, a number of prominent engineers having been invited to discuss the various phases of present day operation and suggest improvements for the future. W. B. Jackson acted as toastmaster.

I. E. Moultrop was the first speaker of the evening, and preceded his technical address with a short talk on the work of the Society, especially as related to the increase of membership campaign. He called attention to the great importance of the boiler room and where the most intelligent supervision wae required, and said that there was a lack of suitable CO_2 recorders, steam meters, draft gage, etc.

J. W. Parker spoke at some length on boiler operation, explaining instances that decided in favor of a large unit. He believed this would work out for better results in the operation of the boiler room, and said that the limit of size had not yet been reached. A very large boiler is not any more difficult to take care of or more expensive to operate than the standard size equipment of such apparatus.

John Hunter stated that he had practically just "come on shore" from marine work. He told of placing wooden patches on the boilers he operated while in the maritime service, and explained in detail how the Missouri Light and Power Plant is operated in parallel with the Keokuk Hydro-Electric Plant, from which 60,000-kw-hr. service is taken.

W. L. Abbott closed the discussion with a talk in which he related his many interesting experiences as chief operating engineer of the largest power plants in the world. He argued for a reduction in the number and size of chimneys, with a corresponding increase in the number of forced draft installations; also for a further reduction of the flue gas temperature by applying the gas to the feedwater system of the plant to a much greater extent than is found in present practice.

PHILADELPHIA, MARCH 14

A meeting of the Society with the Engineers Club of Philadelphia was held in Philadelphia on March 14 and was preceded by the brief transaction of business.

I. E. Moultrop gave the paper of the evening upon Steam Power Plants, which covered a very wide field. Mr. Moultrop described the location and general arrangement of the various plans, facilities for receiving, storing and handling coal, the supply of condensing water, the relative position of boilers, prime movers, switchboards, etc., and the architectural features of the buildings, both exterior and interior. He laid special stress on the importance of better economy in the boiler room and advocated the employment of men of the same grade of intelligence as skilled mechanics and the furnishing of apparatus to indicate the conditions under which the fuel is being burned. The increasing importance of pure feedwater was also pointed out.

The paper was discussed by Wm. Eglin, A. C. Wood, W. C. Kerr, and Mr. McFarren.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

An inquiry has lately been received as to the right of reprinting an abstract from the Foreign Review. In accordance with the policy of the Society, all matter published in The Journal is free for reprinting, and anything tending to extend the usefulness of the Survey is heartily welcomed. As a matter of fact, both American and British engineering papers reprint from time to time articles from The Journal.

THIS MONTH'S ARTICLES

The first section, Air and Gas Engineering and Air Conditioning, contains a detailed abstract of an article on preventing the formation of a mist in factory rooms, and the heating system used in this connection; a valuable discussion of the oscillation pyknometer, an acoustic instrument for measuring the density of gases and liquids, and data of tests on the explosion points of various mixtures of natural gas and air. In the next two sections are given a description of a large heating system where a number of buildings are heated by exhaust heat from gas engines, and some data of tests of a hydraulic air compressor. Under the heading Internal-Combustion Engineering will be found an illustrated description of the new type Delaunay-Belleville carbureter, of the De-Fontaine revolving grate gas producer, and on various methods of governing the water injection in hot bulb engines. The Shop Processes section comprises the first installment of an article on the investigation of the autogenous processes of cutting metals, and on cast-iron founding. The section on Steam Engineering is of particular interest. It includes an investigation of the influence that the temperature of superheated steam exercises on the steam consumption of the engine; on trouble from unclean steam in modern high-duty boilers, and how to avoid it; and on natural steam in Tuscany. The next section contains some data on the influence of arsenic on the strength of rail steel.

A comparatively large number of abstracts are made this month from the proceedings of various engineering societies in addition to those mentioned in connection with the Foreign Review section. The following subjects have been considered: compressibility of ice; use of peat powder as fuel for locomotives; advisability and conditions of using mixtures of coal tar and creosote for wood preservation; tests on concrete columns reinforced with a spiral of steel; how pores in hollow brasses may be closed; heat economies in sugar factories, and the influence of using multiple effects, vapor heaters and vapor pans; air brake performances in actual practice and causes of imperfect operation; nature of steel from the physico-mathematical point of view; trouble from corrosion in tramp steamer boilers, and use of calcinated soda to prevent formation of scale when using sea water; electric train lighting; modern methods of welding; absorption of oxygen by coal; reversing air currents in coal mines and the mechanical structure involved; steel passenger car design; electrical conductivity under varying conditions of cross ties treated with creosote; preservation of wood (in particular use of sugar); testing low-head water turbines (with data on the Holyoke testing plant.)

FOREIGN REVIEW

Air and Gas Engineering, Air Conditioning

EXPLOSION POINTS OF NATURAL GAS MIXTURES (*Explosionsgrenzen von Naturgasgemischen*, Z. Z. Bituchowski and Z. Lahocinski. *Petroleum*, vol. 9, no. 9, p. 605, February 4, 1914. 2 pp. c). The rapid development of the natural gas industry as well as the extended use of natural gas for heating and lighting purposes prompted the author to undertake an investigation of the explosion points of mixtures of natural gas with air.

The explosion points of such mixtures depend usually upon the temperature of the explosion exciter and the gas mixture, on the thermal properties of the gases and their products of combustion and especially on the ratio of mixture of the gas with air. This matter has not hitherto been fully investigated, at least not with regard to the Galizian natural gas with which the authors made their tests. The testing arrangement was as follows:

A gasometer of about 20 liters capacity was provided with an Orsat apparatus and a Hempel explosion pipette in such a manner that the gas mixture could be investigated immediately previous to the explosion. The pipette contained about 150 cm. (9.15 cu. in.), and was provided with platinum electrodes separated from each other at a distance of 2 mm. (0.08 in.), the explosion being produced by an electric spark from a small induction coil excited by alternating current. The natural gas used for the test was taken from the main pipes of a Galizian distributing system, and at the time of the test contained 40 per cent air and had a specific weight of 0.870. The tests were made with air mixtures from 40 per cent up, because previous tests with other kinds of gas have shown that investigations of mixtures containing less than 40 per cent did not present any interest. For the production of benzine, the lowest gasolene obtained from Bitkower crude oil has been used, with specific weight of 0.622 at 15 deg. cent. (59 deg. fahr.). This benzine was selected on the ground of previous investigations because the ability to form explosive mixtures belongs preëminently to the lightest oils, and further, because the properties of these products of fractional distillation approach very nearly to those of pentane with which similar experiments have previously been made. The desired mixtures have been prepared by evaporating small amounts of benzine in a separate gasometer and by passing the vapors into the gasometers with the Hempel explosion pipette. In this manner they could prepare mixtures with the desired content of air.

In order better to determine the influence of the test conditions, the authors have also determined the explosion limits of methane, which was produced in the usual manner, washed in concentrated sulphuric acid and of a specific weight of 0.561 (air = 1). Table 1 exhibits data of the present test as well as those of former tests by Bunte, Eitner and Trautwein. The average temperature at which experiments in the present series have been made was 20 deg. cent. (68 deg. fahr.). From this table it appears that, although according to previous investigations of Dr. Hausmann and Dr. Gruszkiewicz, natural gas approaches methane in its

general properties, it possesses the closest limits of explosibility, while methane has the widest limits, which confirms, by the way, the observations of Eitner that the explosibility of a gas is materially affected even by comparatively unimportant chemical influences. Contrary to expectations, the explosion limits of methane coincide with those of gasolene. These tests seem to show that the utilization of natural gas, in so far as possibilities of explosions are concerned, does not involve any particular danger.

TABLE 1 EXPLOSION POINTS OF NATURAL GAS-AIR MIXTURES

Kind of Gas	Percentage of Combustible Gas in the Mixture			Explosion Limits	
	No Explosion	Explosion Region	No Explosion	Lower	Upper
Methane *	6.0	6.2 to 12.7	12.9	6.1	12.8
Methane	3.6	3.8 to 8.9	9.1	3.7	9.0
Pentane *	2.3	2.5 to 4.8	5.0	2.4	4.9
Benzine *	2.3	2.5 to 4.8	5.0	2.4	4.9
Bitkower gasoline	2.9	2.94 to 8.0	8.2	2.9	8.1
Natural gas	7.5	7.6 to 9.0	9.2	7.55	9.1

* Taken from the experiments of Eitner and Bunte.

THE TECHNICAL IMPORTANCE OF MEANS FOR ELIMINATING STEAM FROM THE ATMOSPHERE IN FACTORIES (*Die technische Bedeutung von Entnebelungsanlagen,* Oscar Gerold. *Dinglers polytechnisches Journal,* vol. 329, no. 6, p. 86, February 7, 1914. 4½ pp., 4 figs. *dg*). During cold seasons in rooms in which a large amount of water vapor is generated, for example, in textile mills, dye works and paper factories, fog or mist is formed in the air causing annoyance and trouble: such a mist is formed whenever the air is supersaturated with water, i. e. whenever the air at the temperature prevailing in the room is unable to hold in purely gaseous suspension the water vapor generated. This is due to the fact that the air is able to take up at a definite temperature only a certain maximum amount of water vapor, and still remain clear and transparent; but whenever the amount of water vapor present exceeds that maximum for the given temperature, the surplus of the water appears to the eye as a fog or mist. In order, therefore, to prevent the formation of fog in the room, either of the following two ways, or both simultaneously, may be resorted to: viz. either the amount of the water vapor generated per unit volume of air present may be reduced or the temperature of the air raised. The latter can be done only up to a certain limit since the presence of workmen in the room makes it impossible to raise the temperature indefinitely.

In order properly to design the apparatus for the prevention of fog formation in the rooms, one must know first the exact amount of vapor generated in the room and, second, must provide means for controlling the temperature of the room. As regards the formation of vapor one has to consider the following: the distinction between evaporation and vaporization; amount of water evaporated as determined from the area of the surface of the water; temperature of the liquid and motion of the air layer in contact with the water; the weight of the water evaporated per square meter of surface may be determined by the following formula:

$$G = \frac{ck\ (S_1 - S_2)}{B}$$

where G is the weight of the liquid evaporated per hour per square meter of the free surface in kilograms; c is a constant depending upon the properties of the liquid under evaporation, its saturation, etc.; k is a factor which expresses the influence of the velocity in the layer of air in contact with the liquid: S_1 is the pressure of the steam corresponding to the temperature of the liquid under evaporation; S_2 is the pressure in the air above it, containing water vapor, and B

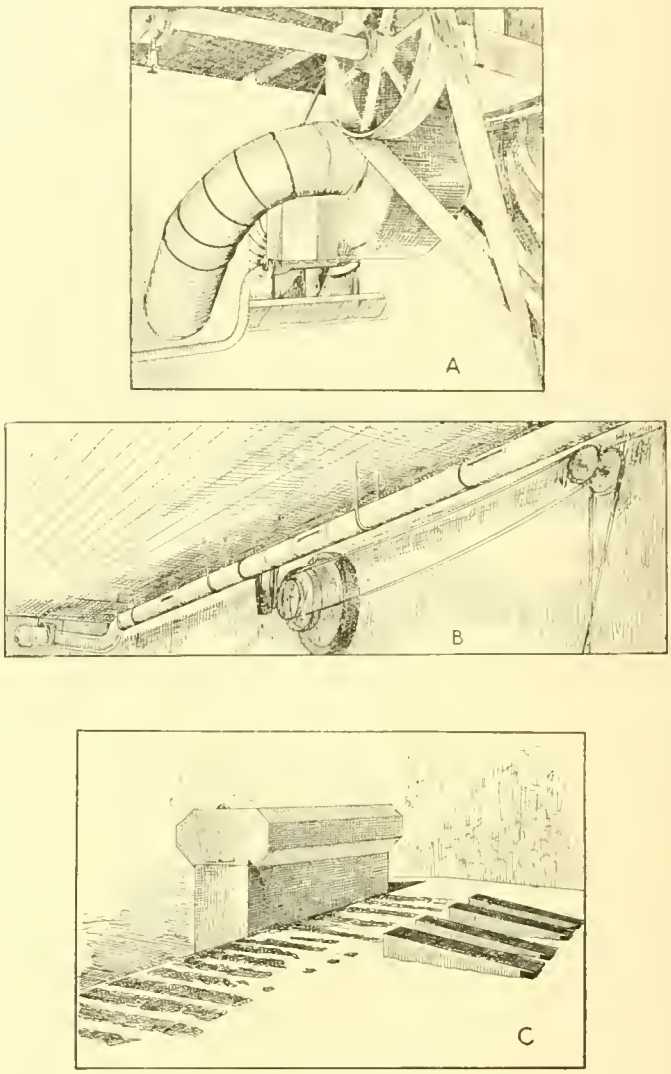


FIG. 1 APPARATUS FOR HEATING FACTORY ROOMS AND ELIMINATING MIST FROM THE ATMOSPHERE

is the barometric pressure in the room (with all the pressures expressed in units of mercury).

After the amount of the liquid transferred into the atmosphere per unit of time is determined with due respect to the external temperature in summer and winter, and under an assumption of a certain internal temperature, the amount of air must be sufficient to take up all the liquid evaporated in a manner such that there should occur no complete saturation. It is, however, important that there should be not only no complete saturation but that the amount of vapor in the air should not be even near the complete saturation point because not only mist in the air, but even the presence of

moisture closely approaching complete saturation point injuriously affects the health of the workmen. If, for example, at a temperature of 20 deg. cent. (68 deg. fahr.) the air is saturated with water vapor to say 95 percent, the human body can no longer evaporate moisture outward, which produces harmful disturbances in the mechanism of exchange of materials in the body and causes an unpleasant feeling which affects the health, efficiency and attention of the workmen. A man can remain for many hours in a room at a temperature of 40 deg. cent. (104 deg. fahr.) if the air is dry, because the body is then sufficiently cooled by the process of perspiration, while in a room with the air saturated with steam at a temperature of 20 deg. cent. (68 deg. fahr.) where the evolution of sweating is absent, the men will very rapidly begin to experience an unpleasant sensation. It is therefore advisable not to permit the humidity of the air to rise above 80 per cent of the saturation limit.

The third magnitude which has to be taken into consideration in the design of the humidifying plant is the amount of heat required to dry the air up to the point at which it can take up all the moisture present. This can be done in the usual manner, but attention must be paid to whether a special heating system is provided for the rooms where the humidifying processes are to be carried out and whether this system of heating can deliver the temperature required in the rooms for this purpose; or whether the heating is provided by means of air driven in by the apparatus used for the humidification itself. In any case it is advisable to supply the air into the rooms under pressure so as to furnish the room with a pressure somewhat above the atmospheric, and by this means to prevent the flow of air into the room through windows, doors and cracks in the walls, as such an influx of air might affect the results. For the proper working of the dehumidifying plant, much depends on the design of the heating apparatus. Fig. A shows a type installed in a paper factory with which it has been possible to effect an extraordinary saving of space, which is of importance since no special room is provided for the installation of the heating apparatus, which has to be placed flat on the wall or ceiling of the room. It shows a low pressure fan with the heating apparatus built onto it, seen in the illustration in the opening left uncovered for this purpose. The fan sucks the air in through a quarter bend from the atmosphere and forces it through the heating apparatus into the distributing piping system. The piping performs the duty of distributing the heat uniformly in the room and, as far as possible, should bring it to the level of the floor as warm feet and cool heads are the most desirable conditions from the view point of efficiency and health of the workmen. The pipes can usually be placed so that they would be in no one's way, in the ceiling or openings of the steel frame, while the outlets for the warm air must be regularly distributed so as to prevent the outflow of the warm air in the form of a violent draft which might become unpleasaut.

Fig. B shows the distribution system over a paper-making machine used for the manufacture of a special kind of paper. The warm air passes through au exhaust chamber in thin multiple layers due to the presence in the box of an adjustable link. The air flows from under the cover and distributes itself over the entire area in a manner such that the warm air passes in between the cover and the water vapor and rises upwards owing to its specific weight. By this means, the ceiling is kept warm and the water vapor is taken up to where the conditions for so doing are most advantageous. The links are built in so that the entire movement of the air which takes place in the ceiling of the machine room is directed toward the air shaft and passes into an exhaust.

Fig. C shows a view of this exhaust shaft as seen from the roof. In order to prevent a lateral formation of mist due to the presence of walls and windows, the pipes are provided with narrow slots which permit of the escape of the warm air sidewise. The heating arrangement of the dehumidifying plaut shown in this illustration is easily adjusted; for example, the temperature in the room can be regulated from any desired place to practically any desired level by moving a simple pointer of a special thermostat.

In the design of all such apparatus must be considered the heat losses due to the flow of the air through the heating pipes at the lowest outside temperature. These calculations do not, however, differ from those usually required for air heating installations and therefore are not reproduced here.

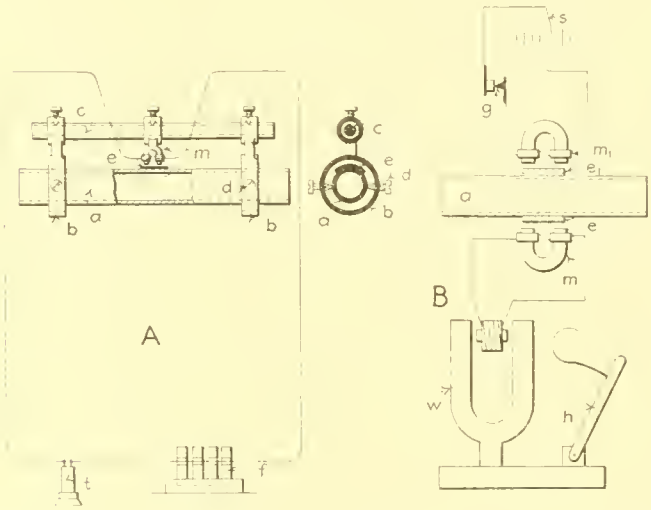


Fig. 2 Oscillation Pyknometer for Measuring the Density of Fluids

The Oscillation Pyknometer, an Acoustic Apparatus for Measuring the Density of Gases and Liquids (*Das Schwingungspyknometer, ein akustischer Apparat zur Dichtmessung von Gasen und Flüssigkeiten*, A. Kalächne. *Dinglers polytechnisches Journal*, vol. 329, no. 6, p. 81, February 7, 1914. 3 pp., 2 figs. *d.*). In various branches of engineering, there is need of an apparatus for making rapid determinations of the density of gases and liquids. While this is not so difficult for liquids, in the case of gases where the densities are very slight, while the technical processes often require a great precision of measurements, the problem is a rather complicated one. It is for this reason that the apparatus described in the present article deserves particular attention. The inventor of the apparatus calls it an *oscillation pyknometer* and it is really an acoustic apparatus for measuring the density of gases and liquids. It appears to be particularly convenient for measuring densities of gases in small enclosed spaces, such as glass vessels, gasometers, cylinders of gas engines, etc., and has the further advantage of permitting the reading of indications at a distance by means of an electromagnetic transmitter.

It may also be used for measuring high densities of gases

at high pressures, in which case, however, it has to be designed in a somewhat different manner. This process is based on the fact that when a solid body moves in a fluid, whether gas or liquid, it carries with it particles of that fluid and thereby suffers a certain apparent increase in mass. If the motion of the body is of an oscillatory character, the apparent increase of its mass may be observed from the change of its natural period of vibration, the frequency of the oscillation of the body increasing in a certain proportion to the increase of density of the medium in which the oscillation occurs. In the present process, the elastic body which performs the oscillatory motions is of the nature of a sounding element, such as a string; it is immersed in the medium under investigation, and the variation of its natural period of vibration as compared with its natural period of vibration when not under the influence of the given medium (when in a vacuum or in a normal medium) is measured, and from the variation of the frequency, the density of the fluid is immediately obtained if the apparatus has been properly and empirically calibrated from observations made on mediums of known densities.

If the variations in the frequency are small as compared with the natural frequency itself, and amount to a few oscillations per second with a natural period of vibrations of several hundred oscillations per second, then the variations are proportional to the corresponding differences in density, which makes the calibration of the apparatus and the reading of the densities a simple matter. This applies, for example, to the case when gas densities are measured in the neighborhood of atmospheric pressure or at pressures not greatly varying from it. In order to measure gas densities by this process, the sounding element must be very light and possess a large surface so that the gas mass carried away by it be as large as possible. In the apparatus as constructed by the inventor it is made of aluminum and has the shape of a pipe with thin walls surrounded by gases inside and out, forming transversal oscillations similar to those of a bar rigidly held at two points. Glass which has a specific weight somewhat below that of aluminum is also suitable, while instead of a tube-shaped body, a plate or bell-shaped body may be also used.

The article describes in detail the construction of the apparatus as well as the devices for measuring the natural periods of oscillation, an important element in the present case.

These are shown in Figs. A and B: *a* is the sounding element, a hollow cylinder which vibrates in its fundamental tone, like a cylindrical bar with free ends. To make this possible, the tube is supported by two pairs of pointed screws *dd* at the two knots of motion, the screws being supported in ring-shaped holders *bb*, movable along a supporting bar *c*, so that they may be located at just the right knots of motion. The bar *c* carries also the apparatus used for the excitation of oscillation and for the measurement of the frequency, both of which may be done in several ways, either by exciting vibrations mechanically and comparing them acoustically with known products of normal sounding bodies, such as a tuning fork, or with a frequency meter, e. g. the Frahm frequency meter with oscillating pipes, or the sounding element may be excited to resonant oscillations by a periodically acting body having similar or perfectly equal oscillations of known frequency. When the exciting frequency and the natural period of oscillations of the sounding body are equal, the largest frequency (resonance) takes place so that from the resonant curve may be derived also the value of the natural period of oscillations. The first form of measurements is shown in Fig. A with the striking hammer omitted, the second system in Fig. B; the transmission of oscillation of the measuring devices in both cases and the excitation of the sounding body in the second case are effected electromagnetically on the telephone principle, the sounding body carrying at the point of maximum *amplitude*, one (Fig. A) and two (Fig. B) iron pieces *e* and e_1, closely opposite to which are located the telephone magnets *m* and m_1 fixed independently of the sounding body. In Fig. B, the coils of the exciting magnets *m* are energized by alternating current produced by the tuning fork *w* with a coil and iron core between its prongs.

This tuning fork must be of the type which permits regulation of the tune, such as the Koenig or Neesen type, but of course any other source of alternating current may be used if its frequency can be maintained sufficiently constant and measured with adequate precision, this being of great importance in the present case. The vibrations of the sounding element produce in the coils of the magnet in the measuring circuit *m* in Fig. A and m_1 in Fig. B an alternating current of the frequency of the oscillating sounding body which may be measured either directly by including in the circuit a proper device, such as the telephone *t* and frequency meter *f*, but more conveniently by determining the amperage of the alternating current generated and the excitation frequency which gives that maximum amperage obtained (Fig. B) by means of a string galvanometer *s* the current being rectified at *g* where a crystal rectifier similar to a crystal detector used in wireless telegraphy may be inserted.

The precision of measurements and of the oscillation pyknometer depends in the first instance on the ratio of the mass of the sounding body to that of the gas and liquid carried away by it, and in the second place on the sensitiveness of the auxiliary apparatus, oscillation exciters and frequency meters, and so far it has not been possible to establish the exact limits for the precision of the apparatus, the relative sensitivity of the apparatus being apparently greater for denser gases than for lighter ones, but the sensitivity of the apparatus may be materially increased by using a lighter oscillation element. The difficulties of construction are much less when denser fluids, such as compressed gases or liquids, have to be measured.

Heating

Utilization of Exhaust Heat from Gas Engines for the Heating of Buildings (*Abwärmeverwertung von Gasmaschinen für Fernheizung, Stahl und Eisen*, vol. 34, no. 8, p. 318, February 19, 1914. 3 pp., 3 figs. *d*). In the plant of the Adolf Emil Works, the administration office building, the employees' club and the houses where the employees live are heated throughout by water, which is heated by the exhaust gases from the large gas engines.

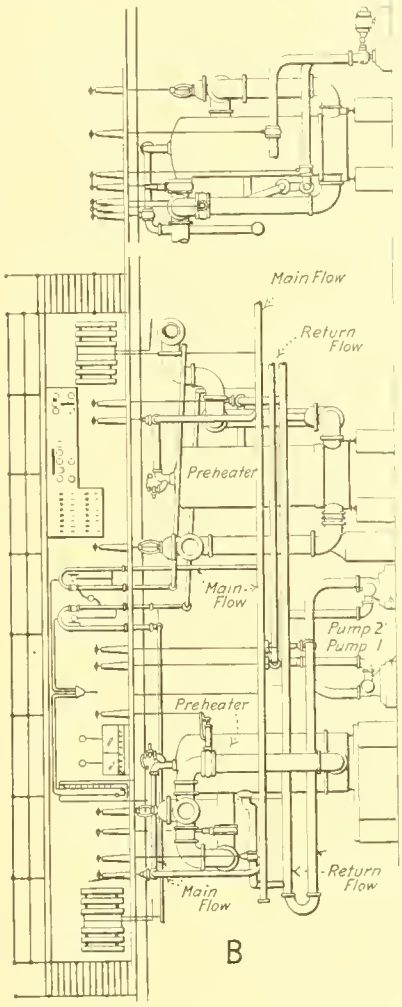
In addition to the above-mentioned buildings, the gas central station and automobile garages are fed by heat from the same station, and several other smaller plants, as indicated in Fig. 3 A. The largest heat consumption per hour of all these buildings, at outside temperature of—20 deg. cent. (4 deg. fahr.), is approximately 3¼ millions WE (12,870,000 B.t.u.) for the delivery of which in the gas central station four preheaters are provided with an hourly output

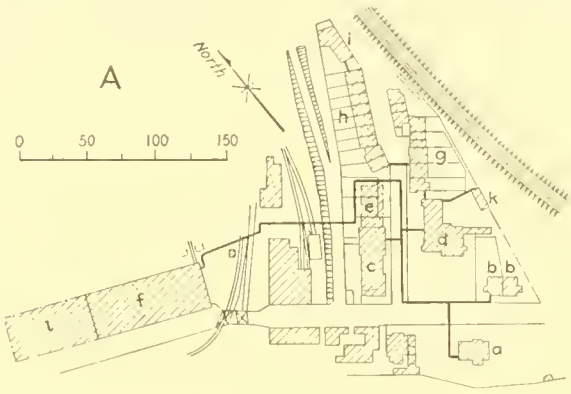
of 800,000 to 1,000,000 WE (3,168,000 to 3,960,000 B.t.u.), each heated by the exhaust gases of the large gas engines.

These preheaters are designed as tubular boilers with rolled-in tubes and cast-iron jackets, the water playing around the tubes while the gases pass through the tubes. To produce an eddy motion in the exhaust gases and so raise the amount of heat which they give up, sheets, with spiral windings, are built-in in the tubes. The most important property of hot water heating, the common heat regulation, is secured by a corresponding regulation of the temperature of the heating gases in large gas engines. Cold water is injected into the exhaust gases in the usual manner shortly before their exit from the cylinder, and the amount of this injection is regulated. The temperature of the mixture of steam and gas may therefore be regulated to any desired amount from 100 to 600 deg. cent. (212 to 1112 deg. fahr.).

To determine the temperature in the exhaust in front of the preheaters, electric distance thermometers are installed, connected with similar thermometers showing the temperature of the hot water and various room temperatures in the colony of buildings served by the plant. In addition to that, the distance thermometers are connected with an alarm device in such a manner that if the temperature of the hot water exceeds a certain amount, the device lights up a special little lamp and rings a signal bell. This device is independently installed for each preheater, but all the distance thermometers measuring room temperatures, have a common indicating apparatus where a switching device for cutting-in any separate thermometer is provided. Safety valves are provided to insure the preheater against explosions which might take place owing to carelessly closed valves or failure of the pumps. The circulation of hot water in the system is taken care of by a centrifugal pump direct connected to a direct-current electric motor. A second pump serves as a reserve. The entire arrangement of the pumps and preheating boilers, as well as the general scheme of the electric connections is indicated in Fig. B. The pumps and preheaters are installed in the basement of the gas central station, but the gate valves and starting devices may be actuated from the machine room on the next floor. As the various buildings are operated in series, one after another, the starters are designed in a manner such that they regulate the speed of rotation so as to regulate also the flow of water to the desired dynamic pressure of the pumps on the basis of the indications of the hydrometer, since in large plants a direct regulation by pressure cut-off valve or shunt piping with an adjustable slide valve is difficult to design and cannot be operated without considerable power losses. The amount of water can be easily determined from the readings of the ammeter, voltmeter and hydrometer when the efficiency curves of the motor and pump are known.

As shown in Fig. B, the hot water is driven by the pump





a Director's House; *b* Dwelling Houses of the Engineers; *c* Administration Building; *d* Employees' Casino; *e* Supplementary Administration Building; *f* Gas Central Station; *g* Eastern Section of the Employees' Colony; *h* Western Section of Employees' Colony; *i* Hall; *k* Automobile Garages; *l* Extension of the Gas Central Station.

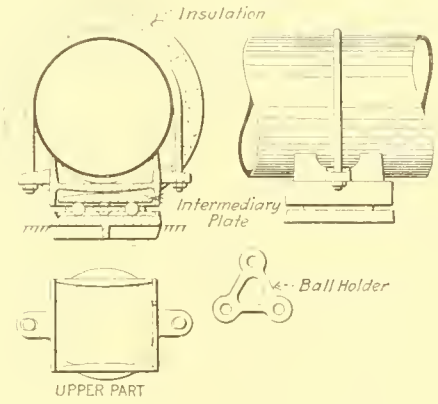


Fig. 3 German Heating System Operated with Exhaust Heat from Gas Engines

through the preheater, and, after being preheated, goes into the main pipe from which the pipe for heating the gas central station branches off. Further, as shown in Fig. A, the main pipe leads to a branch pipe of 850 mm. free diameter (34 in.), in which are also located the electric cables for light and power transmission as well as the distant thermometer wires, all of these being placed in cast-iron conduits. On the pipe corners as well as at every 20 m. to 25 m. (say 65 ft. to 98 ft.) are placed inspection shafts and manholes. The main piping, branch piping and distributing piping are everywhere autogenously welded, which was found to be very convenient when the welds are made in a workmanlike manner. All the distant piping rests on ball bear-

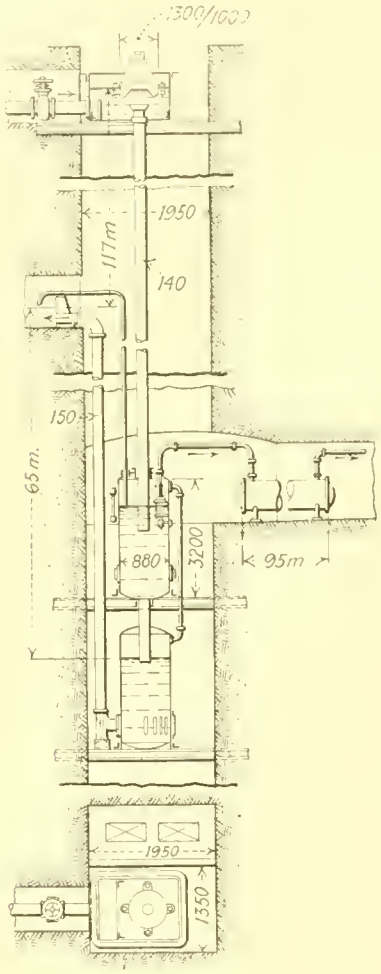


Fig. 4 Hydraulic Air Compressor Plant

ings which admit a displacement of 90 mm. (36 in.) for pipe expansion. The compensating displacement of the bearings are dimensioned accordingly. As shown in Fig. C, the ball bearings setting consists of a crown plate, three balls kept in position in a movable plate with three holes, and an intermediate plate with the uniform transmission of pressure on one hand to the bearings, and on the other hand to the upper part of the setting. As the initial designer of the plant had to consider the possible trouble in the operation of preheaters, exhaust gas piping, etc., as a reserve for preventing disturbances in the operation of the heating system, in the casino, ten cast-iron sectional boilers with a total heating surface of 356 qm. (3831 sq. ft.) have been installed where there is also a reserve pump for water circulation. The article gives some further details of the installation, but does not contain any information as to costs or efficiency nor does it refer to any tests of the plant.

Hydraulics

Novelties in Hydraulic Compressor Design (*Neuerungen an Hydrokompressoren*, Heirich. *Dinglers polytechnisches Journal*, vol. 329, no. 7, p. 100, February 14, 1914. 2 pp., 1 fig. *d*). The article gives some rather incomplete data on a hydrocompressor installed in a German mine. Fig. 4 shows the general construction of this compressor which was built about four years ago and tested in 1910 when the data given in Table 2 were obtained. This table shows among other things that the determination of the useful effects of the compressor in accordance with the adiabatic formula has no sense and leads to results materially more favorable than those actually obtained.

The hydrocompressor compresses the air not adiabatically, like the mechanical compressor, but isothermally, as is proved by thermometric measurements. The suction apparatus takes in the air in the form of jets enclosed by streams of water and thoroughly mixes it with the water so that it is finally in the form of numberless bubbles surrounded by water which produces perfect cooling. Owing to this fact,

TABLE 2 DATA OF TESTS OF A HYDRAULIC AIR COMPRESSOR

Head 117 m (say 384 ft.); air compression 6.2 atmospheres gage

Quantity of Water, Liters per Sec.	Water Power, H.p.	Quantity of Air, Liters per Sec.	Compression Output		Efficiency	
			Isothermal	Adiabatic	Isothermal	Adiabatic
18.0	28.4	7.2	18.9	25.6	0.66	0.90
30.5	47.6	10.8	28.5	38.5	0.60	0.81
32.2	50.2	11.2	29.5	40.0	0.59	0.80
35.7	55.6	11.4	29.9	40.4	0.54	0.73

the power required to effect this perfect isothermal compression is considerably less than when the compression takes place adiabatically, i. e., with the simultaneous heating of the air. The compressor shown in the drawing was investigated last June by some engineers who have found a number of defects in the construction of the air suction apparatus and separator. The required alterations in both are said to have been made and the efficiency materially improved thereby. The article does not fully state, however, what alterations have been made or how.

In order to be able to measure the air sucked in by means of an anemometer on the suction head of the apparatus, an air-tight sheet-iron funnel has been built in with an upper cylindrical section with a diameter of 250 mm. (say 10 in.).

The water is measured by filling the outlet tank, and calculation has shown volumetric efficiency of 90 per cent. In order to improve the separation of the air, under the air separator a second one has been built in, correspondingly prolonging the ascending pipe and adjusting the air separation in a manner such that the compressor works constantly with the pressure of 6.5 atmospheres gage. For this purpose, in the air outlet pipe behind the air separator, a throttling valve has been built in, arranged in such a manner that the controlling manometer in front of this valve shows a constant air pressure of 6.5 atmospheres. To the throttle

valve was connected an outlet air pipe for measuring the outgoing air; numerous measurements show that the outgoing volume of air is about 90 per cent of the incoming air as measured at the head of the suction system, 10 per cent having evidently been lost through joints which were not air tight. The output efficiency, or the ratio of the air delivered to that actually taken in by suction is therefore 90 per cent and the mechanical efficiency, i. e. the ratio of the actually useful output to the theoretical water output is $0.90 \times 0.90 = 81$ per cent. For controlling the anemometer measurements, a measurement by means of a calibrated tank has been made, for which the air collector of 350 mm (14 in.) diameter and 95 mm (3.8 in.) long served as a calibrating tank. This measurement has shown a small difference of 0.04 cbm/min. as against the anemometric measurement, which may be ascribed to lack of air-tight connection in the air collector with its 32 pipes. Tests have shown however that by means of autogenous welding, absolutely air-tight joints in the collector may be obtained, in which case the efficiency of the compressor would be raised to 90 per cent.

Internal-Combustion Engineering

Governing the Water Injection in Hot Bulb Engines (*Regulierung der Wassereinspritzung bei Glühkopfmotoren*, A. Dussmann. *Der Motorwagen*, vol. 17, no. 5, p. 93, February 20, 1914. 3 pp., 4 figs. *dp*). In crude oil engines with hot bulb ignition, when run at high duty, some arrangement must be made for maintaining the hot bulb at a constant temperature. At low loads, water injection, which is the usual means of regulating the temperature, is not necessary, but has to be used when running at high load. This involves very undesirable complications, not so much because the water attacks the cylinder walls as because it is difficult to regulate the water injection, especially in the case of small units or units used in farm machinery, where an experienced engineer is not available, and, as a matter of fact, even an experienced operator has not always been able to regulate the injection in an absolutely proper manner.

A device which would make this adjustment automatic, if sufficiently reliable and cheap, would materially extend the use of this type of prime movers. The author describes several methods proposed to solve this problem; the simplest way would be to combine a fuel pump with the water pump and thus regulate the injection (Fig. A). Both pump plungers are driven from a common cam. The lever *a* actuates the suction valves of both pumps in such a manner that at the suction stroke they are lifted and at pressure stroke closed by springs. The regulator, driven by helical wheels, displaces the fulcrums of the lever *b* in such a way that the suction valve, in accordance with the load on the engine, may remain open for a shorter or longer time during the pressure stroke, so that the liquid which has not been used may flow back into the suction space. By means of this construction it is possible to govern, by one governor, both the fuel and water injection. The author claims to have made extensive experiments with such a pump arrangement and to have established the fact that this system of government is of only small use and does not eliminate in the least the necessity of regulation by hand. For various loads, the quantity of water to be injected is not in constant ratio to the quantity of fuel and therefore the water pump and fuel pump must be governed by two independent governors; such an arrangement would make a small unit far too expensive.

Another solution lies in the utilization of temperature

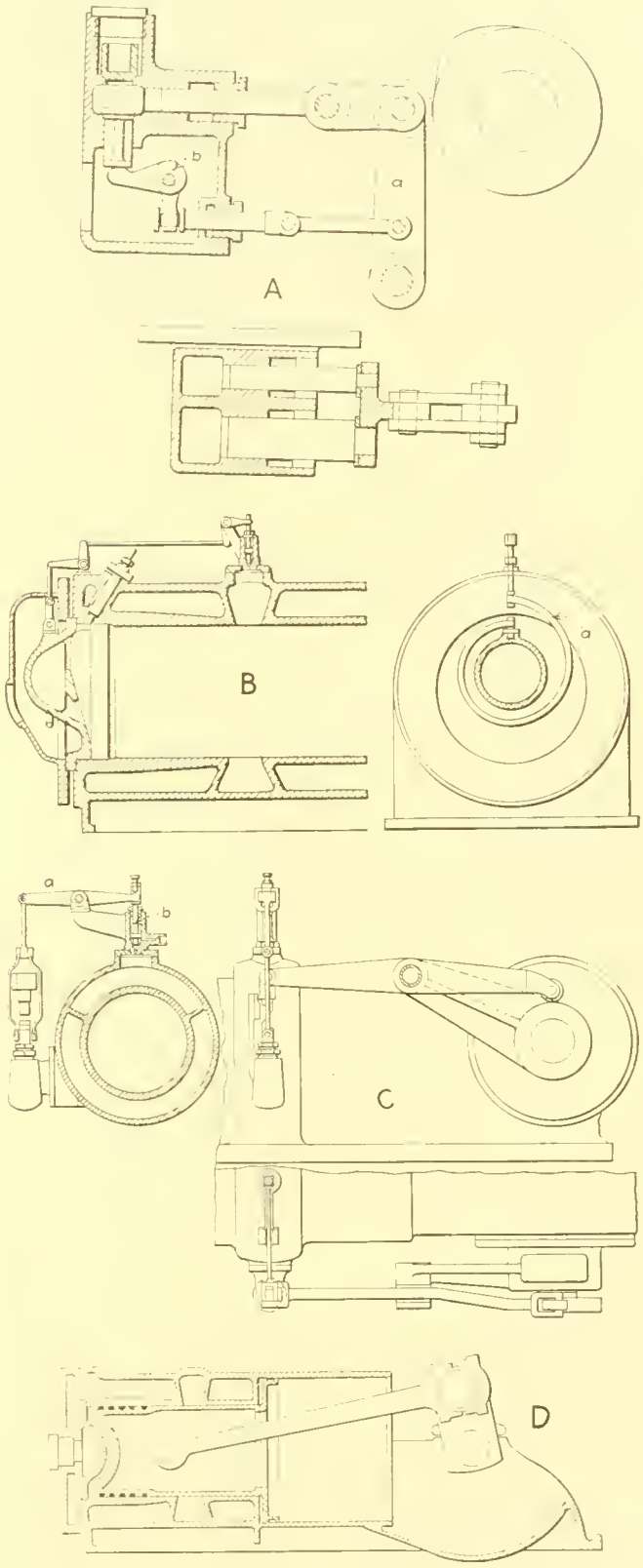


Fig. 5 Various Systems of Governing Water Injection in Hot Bulb Engines

exchange of the hot bulb itself. Theoretically this appears to be correct, since all that the water injection has to do

is to regulate the temperature of the bulb. Fig. B shows how this is done. A ring *a* expands when the bulb becomes too hot, and through its expansion raises the stem of the needle valve and thereby increases the cross-section of the water passage. There are also used pendulum governors especially adaptable in this case because the hot bulb engine does not require great precision of operation. When such a governor is used, the fuel admission is governed on the hit-or-miss principle. During the idle stroke the water injection is not required, since no combustion takes place, and there can be no rise in temperature of the bulb; the elimination of the water injection during the idle stroke is secured by connecting the water inlet valve with the pump plunger. Fig. C shows a very simple embodiment of this principle. The fuel pump is located in the neighborhood of the injection nozzle in order that the injection should occur with precision. Long piping leads to an after-burning of the charge due to the expansion of the pipe walls during the pressure stroke and their contraction after the end of the stroke. If it is desired to drive the fuel pump in a simple manner, this may be achieved only by using a long lever which must be of generous dimensions in order to prevent the rise of spring action. In calculating the dimensions of the lever, the plunger must be assumed to work at about 100 atmospheres. The fulcrum of the lever as shown in Fig. C may be secured in the simplest way by means of an arm fixed on the gear bearing. The lever *a* is driven from the plunger by means of a connecting rod, raises at an ignition the valve *b* and makes water injection possible. If, at the higher speed, the knife is so accelerated by the rise of *c* that it no longer comes in contact with the knife of the plunger, the stroke remains idle and the valve *b* is not opened. Above the valve is located an adjusting screw which permits of the adjustment of the stroke. The author tested this construction on a 4 and 15 h.p. engine and found that it works very well. Regulation by hand was no longer necessary, either when the load was taken off the brake entirely or the brake loaded to maximum. The only disadvantage of this system is the noise produced.

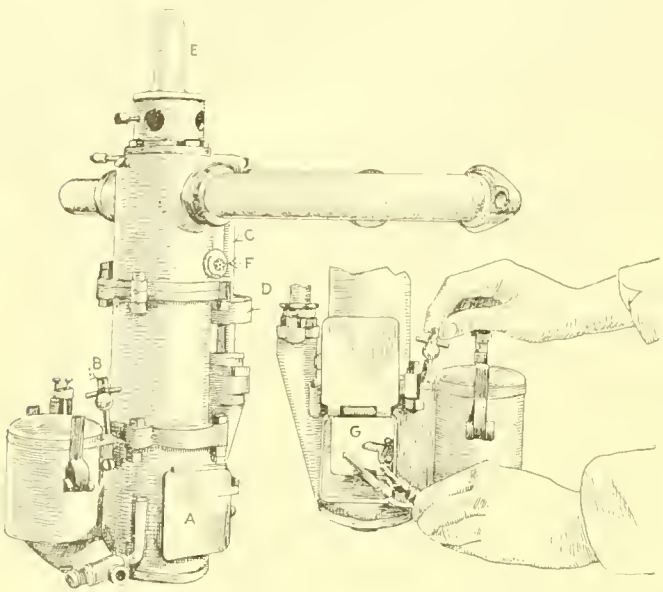


Fig. 6 Delaunay-Belleville Carbureter

If larger machines are used, in which more exact governing is required, the system of the crude oil engine must be changed and in place of the low pressure engine, a middle pressure engine has to be used. The compression pressure must be raised to 18 to 20 atmospheres, and the fuel similar to the practice in Diesel engines, must be injected only a little while before the dead point. The hot bulb cannot then be installed in the usual manner, since at high pressure it would easily break; it has to be provided with openings as shown in Fig. D, so that the walls of the hot bulb should no longer be subjected to pressure, nor affected by unequal expansion.

Such an engine does not require water injection at all, and no preignition can occur in it since the fuel is admitted to the combustion chamber only when the explosion is apt to take place. The combustion process in such an engine is, however, entirely dissimilar to that of the usual hot bulb engine, and while in the latter the desired gasification of the fuel is effected by the presence of the glowing bulb, in the middle pressure engine it approaches more nearly that of the Diesel engine, with the combustion taking place on the introduction of a finely divided fuel.

The New 25-30 H.P. Delaunay-Belleville Car (*La nouvelle 25-30 chevaux Delaunay-Belleville*, E. Pepinster. *Omnia*, vol. 9, nos. 425-428, February 21, 1914. 4 pp., 6 figs. *d*).

The carbureter in the new 25 to 30-h.p. Delauney-Belleville car is of unusual construction and dimensions. While in the standard types of car the carbureters are becoming smaller and smaller, the new Delauney-Belleville carbureter is large (larger than all its predecessors). This is due to the fact that the standard carbureter is expected to adapt itself to all kinds of engines by means of some adjustment which varies for each individual case. It must therefore satisfactorily meet such requirements as are common to all kinds of engines and the number of such requirements is naturally smaller than that of a single type of engine. On the other hand, the Delauney-Belleville carbureter is made to work with the Delauney-Belleville engine only, but has to satisfy all the conditions presented by this engine. It is therefore both more complicated and more voluminous than the standard carbureter, but provides an incomparably greater collaboration between the engine and the carbureter. The principle of its construction is as follows:

A normal-run spraying nozzle creates a rich mixture which the supplementary air adjusts more or less in accordance with the more or less energetic suction of the engine. The slow-down spraying nozzle, which is merely an auxiliary carbureter, feeds the engine at low speed. The engine is a six cylinder and the normal speed carbureter is made in two units, each unit taking care of three cylinders and having its normal speed spraying nozzles and diffusors independent for each group. On the contrary, the auxiliary carbureter, as well as the supplementary air valve, are common to both groups, and with one-sixth of the heat generating circulation around the diffusors, the slow-down carbureter and the supplementary air piping, one can easily see why this apparatus works in about the same manner as a small gas factory. The supplementary air reaches the spraying nozzle by two tubes which pass through the jacket of the engine and collect air preheated by convection around the exhaust gas manifold. The carbureter is not therefore in danger of troubles due to lack of preheating, while on the other

hand, precautions have been taken to prevent excess of preheating. To do this it is necessary only to open the lateral seams and close the spraying nozzle chambers, after which air is taken directly from the atmosphere.

The installation and regulation of the new carbureter is both simple and successful. The slow down is regulated by a large knurled button concentrical to the auxiliary carbureter. As to the two normal-speed spraying nozzles, they are twin connected by means of a very original device. The two nozzles are simply placed on their seats and maintained in place by a little oscillating finger. When this finger presses on the common seat of the spraying nozzle they become stationary, but when the finger lifts, they can both be moved simultaneously. The efficiency of this carbureter is excellent owing to the simple paths of the gas and to the division between the two groups of cylinders. The suction of the motor is not opposed by any counteracting partial vacuum and can be fed with the same facility at high speeds as at low speeds. In addition, the supplementary air enters the piping immediately behind the narrow zone of the diffusor cones, i.e. way in front of the valves, which arrangement is claimed to ensure the absolute homogeneity of the mixture. The car possesses several other interesting details such as a new type of gear drive, which cannot, however, be described here owing to lack of space.

De-Fontaine Revolving Grate Gas Producer (*Drehrostgenerator System de Fontaine*, Gwosdz. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 7, p. 78, February 13, 1914. 1 p., 2 figs. *d*). The technical and commercial success of the Kerpely rotary grate gas producer brought about a number of designs tending to improve or displace that type. In the one produced by de Fontaine & Co. in Hanover, the gas producer itself (Fig. 7) consists of a round shaft made of fire proof brick and jacketed with wrought-iron sheets. On top it has a charging device operated either mechanically or by hand; at the bottom, a grate, centrally rotatable, consisting of a cast-iron ash seal with the grate structure in the middle. The ash seal is filled with water in the usual manner so as to seal the inner part of the shaft away from the atmosphere. It has a worm thread on its inner surface placed spirally in stages, ending in blade-shaped surfaces, backwards, in the direction of rotation.

The most peculiar part of the construction is the central grate structure provided with worm-gear shaped stages and jaws. On the surfaces which distinguish the jaws and form the front surface of each jaw stage are located the outlet openings for the blast. The worm-thread grate, with its stages, gradually lifts and lowers the fuel column and thereby prevents the formation of cavities and suspended slag in the zone of gasification. Further, the jaws break up the slag which might accumulate between the grate and the bottom of the shaft, which is helped also through the bearing ring of the producer jacket being also provided with worm thread opposite to those of the grate elements. The worm thread of the bearing ring and of the grate elements therefore form a sort of conveying device for the slag.

An important element for the uniform operation of a rotary grate gas producer is to hold open constantly the outlet openings for the blast. In older constructions this was done by fitting these openings with special covers, but this had the disadvantage of permitting the flow of air downwards only on account of which only a comparatively small grate area and high blast pressure could be used. Since in the present gas producer, the blast openings are located in the undercut front surfaces of the jaws, a very advantageous grate area is obtained, while the blast can be directed upwards without any danger of the outlet openings being clogged up; since the grate moves in a direction opposite to that of the blast slots, the slots are at all times kept free from ashes and slag which might be deposited over them. A further important advantage of this design is that the blast openings are distributed over the entire shaft cross-section with extreme uniformity.

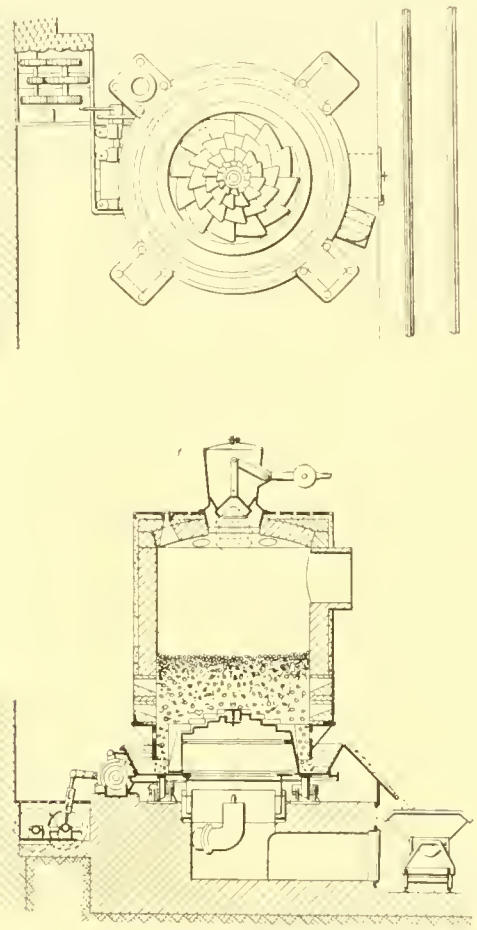


Fig. 7 De-Fontaine Revolving Grate Gas Producer

Shop Processes

Progress in the Production and Testing of Cast Iron (*Fortschritte in der Herstellung und Prüfung von Gusseisen*, Schulz. *Verhandlungen des Vereines zur Beförderung des Gewerbefleisses*, no. 1, January 1914, p. 53. 12 pp., 2 figs. *gp*). The paper discusses the above question from many points of view, such as the effort to conduct furnace operations in a more rational and scientific manner, special construction for the improvement of the quality of the castings, addition of auxiliary materials, reduction of defects in castings and creation of new testing methods for use in connection with cast iron, and standardization of specifications.

A scientific system of furnace operation may be promoted by (*a*) the establishment of definite rules for the classification of various grades of cast iron; (*b*) by constant control of auxiliary materials with respect to their quality

and weight; (c) by the installation of special laboratories, etc. The author points out how, within the last few years, in most of these respects, great progress has been achieved. With respect to coke, the main requirements are high heating values, which may be obtained with a minimum carbon content of 85 per cent. low oxygen content not exceeding 8 to 10 per cent and low sulphur not in excess of 0.8 per cent. The limestone must contain low silicic acid (below 3 per cent) and as low sulphur as possible (below 2 per cent) and must be in small pieces. The importance of using only the correct weights of these materials has been realized to such an extent that a German concern in Darmstadt has, for example, a special weighing arrangement with a locking device, the key of which is kept by the foreman for the purpose of making it impossible for the men to vary the proportion of additions.

To improve the quality of the castings, special cupolas have been built, such as the cupola for tempered castings, which, through a special arrangement of blast admission and construction of the tuyeres, permits of a certain superheating of the material in the cupola. By means of four powerful spindles the hearth of the cupola can be removed and gradually lowered or raised; the blast is admitted through a lower primary and an upper secondary row of tuyeres. The

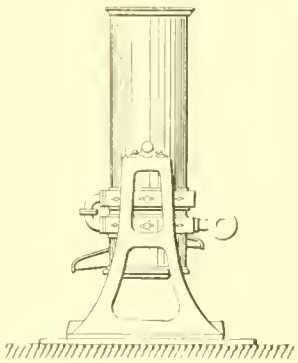


Fig. 8 Cupola for Tempered Castings

main blast is admitted into the lower main chamber and from there is introduced into the upper chamber by means of two one-eighth bends which may be cut off by dampers. The upper tuyeres are smaller than the lower ones and are arranged in staggered fashion with respect to the lower ones. The former is mainly to force the blast which was led in through the lower tuyeres more toward the inside of the shaft and produce a more extensive action of the oxygen content in the blast on the fuel. Fig. 2 shows such a type of cupola only tilted.

In order to improve the quality of cast iron used for special purposes, certain auxiliary materials have been added to it, giving sometimes quite favorable results. Many such materials may be used, but the following are the most important:

Charcoal Pig Iron. The addition of charcoal pig iron is of particular importance for the production of chilled rolls, armor plate and so on, since it gives to the casting a density and strength of structure and a very hard, smooth and nonporous surface. *Osann* published a table showing the chemical composition of such chilled castings where the very low silicon (0.5 to 0.7 per cent) and manganese (0.4 to 1 per cent) used attract particular attention. The addition of *steel shavings* tends to reduce the silicon and carbon contents and to produce thereby a fine-grained, strong texture, but such additions require a longer time and higher temperature for melting, in view of which facts they are often introduced into the cupola together with the coke charge. From the *Diller* tests of additions of steel and ferro-silicon, it appears that an addition of 12½ per cent of steel increases the strength by 25 per cent and a 25 per cent addition increased the strength of the casting 50 per cent; but a higher increase of strength with greater additions of steel could not be observed. The Borsig Co., of Tegel (near Berlin), has lately introduced the addition of iron briquettes with a large number of cavities; these briquettes are produced without any binder, and melt, therefore, much easier than ordinary steel shavings. Such briquettes, whether produced without further additions or with the use of lime water, reduce the carbon and raise the silicon waste as well as the ability of the iron to take up sulphur, but leave the manganese contents unaffected; the castings produced with the addition of briquettes show a finer grained fracture, are much less subject to hardening than the ordinary cast iron, are easily machined and appear to be very strong.

Additions of Titanium and Thermit. These additions have been made either in the form of titanium alloys such as ferro-titanium or as thermit-titanium. By the addition of ferro-titanium have been produced dense, free from porosity castings showing a higher resistance against shocks, higher strength, and better ability to be machined and polished than ordinary castings. On the other side, however, *Treuheit* has found from careful tests that titanium alloys only partly with cast iron, and that although it is a very good deoxidizer, aluminum is better suited for this purpose.

The *thermit titanium* investigated by Goldschmidt is claimed to produce a casting free from porosity and of good quality. As the thermit packed in cartridges must be immersed by means of an iron rod under the surface of the metal bath, which produces a violent boiling of the bath, this process is somewhat complicated and not entirely exempt from danger. The Titanium Company of Dresden claims, however, to have obtained by this means a material increase in the strength of casting at a cost of the addition of 0.25 per cent of titanium.

The addition of *vanadium* also has a deoxidizing effect, and, according to tests of several investigators, increases the strength of the material, at the cost, however, of elongation. Hatfield shows that vanadium prevents the separation of carbon as graphite and raises the stability of the carbides. While in America, additions of vanadium up to 0.1 per cent have proved to be of advantage for locomotive cylinders, its use in the foundries in Germany, on account of the high cost of vanadium, is only limited. *Ferro-silicon* is probably most widely used as an auxiliary material. It improves the mechanical properties of the casting and favorably affects the separation of graphite. Tests made by *Outerbridge* and *Westhoff* have shown that ferro-silicon when added in the ladles may be used to produce from the same heat various grades of castings, while recent tests by *Lissler* have shown that a large amount of ferro-silicon helps to produce castings unaffected by acids to such an extent that they may contain any kind of acid, including hydrofluoric.

The disadvantages of the addition of ferro-silicon lie in the fact that the castings, after pouring, undergo a strong contraction and are therefore brittle. The addition of *alumi-*

num does not entirely eliminate this disadvantage. Besides this, ferro-silicon when subjected to the influence of humidity is decomposed and may cause dangerous explosions or poisoning. This may be obviated by covering the ferro-silicon with paraffin and, above all, in taking care that the ladles and vessels are perfectly dry and well preheated. *Piping* may be avoided by making the risers or cropheads so large as to take up the entire liquid part of the iron in which the pipe may form. Thus, *Messerschmidt* quotes minimum values for risers used in casting steam cylinders. The formation of pipe also may be kept down by the use of iron low in phosphorus (0.1 per cent).

As regards the production of *internal stresses* in castings, the author recommends the usual care in avoiding sudden contractions of area, and in addition states that they may be minimized by reducing the manganese and sulphur, as shown by the tests of *Keep* and *West*. *Porter* shows further that the formation of blow holes is invariably increased by the use of cast iron in which there are combinations of sulphur with a varying percentage of oxygen. Therefore only iron, made of easily reduced ores and produced in a furnace at a not too rapid rate and with a sufficient amount of fuel, should be used.

As regards new methods of testing, the author calls attention to the fact that a number of investigators have lately thoroughly studied the conditions which affect the taking of samples. It has been shown, for example, that the results of carbon contents determinations are materially affected by the fact of whether the shavings taken are thick or thin. The sulphur contents determinations are affected by the sample being taken from the upper or lower part of the casting, the upper part generally being richer in sulphur. The silicon determinations depend upon whether the sample is taken from the central part of the casting or from its periphery, since, as has been shown by *Martens* on steel tests, the silicon content at the rim is much greater than that at the hub. The same is also true for phospborus and manganese; the phosphorus content varies during pouring, which easily produces segregation. The properties of the casting are also affected by the rate of cooling and thickness of the piece, since the graphite contents are lower in pieces of small cross-sections.

As regards the methods of making rapid analyses, the system used in the Krupp laboratories deserves particular mention, since there, in 1909 and 1910, they made 1500 or more daily analyses. Special methods have been worked out to make rapid and sufficiently reliable determinations of carbon, silicon, manganese, phosphorus and sulphur. The author indicates briefly the processes used for the determination of these materials by various chemists.

Investigation of Autogenous Processes of Cutting Metals (*Untersuchungen über autogene Schneidverfahren*, R. Plinienger. *Zeits. für komprimierte und flüssige Gase*, vol. 16, no. 1, p. 6, January 1914. Serial article, not finished. *cA*). While the process of cutting metals by a mixture of oxygen and air or acetylene is no longer new, the details of the process have not as yet been fully established. The author, in his tests executed in the laboratory of the chemical factory of Griesheim Elektron, May to August 1912, determined to investigate the following points:

a The influences of the various percentages of oxygen on the speed of cutting and oxygen consumption

b The constitution of the chips produced with various materials and the determination of the theoretical amount of oxygen consumption

c Investigation of the influence of temperature of oxygen, the material cut and determination of temperature in the cut, by means of a Wanner pyrometer

d Investigation of the surfaces of cutting with relation to their aspects and the possibility of their application in engineering

e Investigation of the metallographic variations produced in the metal

For the tests, sheets SM-1, of uniform quality and carbon content of 0.12 per cent and of the following dimensions:

(1) d = 20 mm.—0.8 in.
(2) d = 40 mm.—1.6 in. } size 1 m. x 2 m. (3.28 ft. x 6.56 ft.)
(3) d = 60 mm.—2.4 in.

were used, and in addition, a sheet of nickel steel was investigated with a content of nickel of 22.25 per cent and 40 mm. (1.6 in.) thick. The length of cut in all cases was

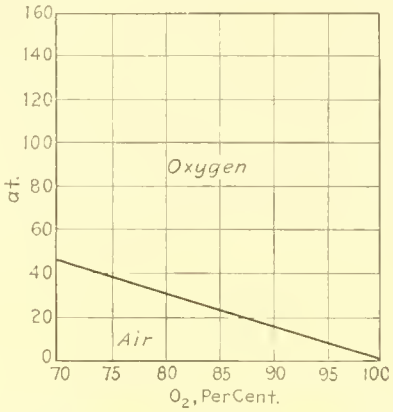


Fig. 9 Diagram for Determining the Oxygen Content (percentage) in a Bottle Containing a Mixture of Oxygen and Air

500 mm. (say 20 in.) and the width of the strips cut off was always 25 mm. or 1 in.

In this test oxygen was used, which was obtained from liquid air by means of rectification, while its contents was established in one of the following two ways: Generally air was pumped in the compressor house into a bottle, which was then filled up with oxygen to a pressure of 150 atmospheres, respective amounts of air and oxygen being determined approximately from the chart as shown in Fig. 1, in which the abscissae indicate the desired percentages of oxygen while on the ordinates are plotted the necessary amounts of air in atmospheres.

This method, however, gave only approximate values, and when the percentage of oxygen was desired to be known exactly, air and oxygen were allowed to flow through two different bottles (the air at a pressure of 170 atmospheres), the flow continuing until the mixture was brought up to the desired percentage. Sometimes, however, to obtain the desired contents of oxygen, as many as 30 analyses were required. These analyses were made with special testing glasses calibrated on the Bunte burette with pyrogallol as the absorption liquid. To obtain the greatest possible uniformity of the tests, the same operator was employed to make all the cuttings, thus eliminating so far as possible the influence of the personal peculiarities of the operator. He was connected with the autogenous cutting of metals almost

from the inception of this process, and it had been observed that with the same consumption of oxygen, he had obtained an approximately uniform speed of cutting. The author gives several photographs of pieces cut at various speeds. Fig. 2 shows a mixture where 98.5 per cent of oxygen was used.

If the speed of cutting is too slow the oxygen jet eats into the metal; if too great, the cut is apt to be interrupted. The various speeds of cutting can be easily recognized from the appearance of the edges of the cut, so that after a certain amount of experience one can easily determine at which speed the cut was made. With the oxygen content less than 85 per cent, it was not always possible to adhere

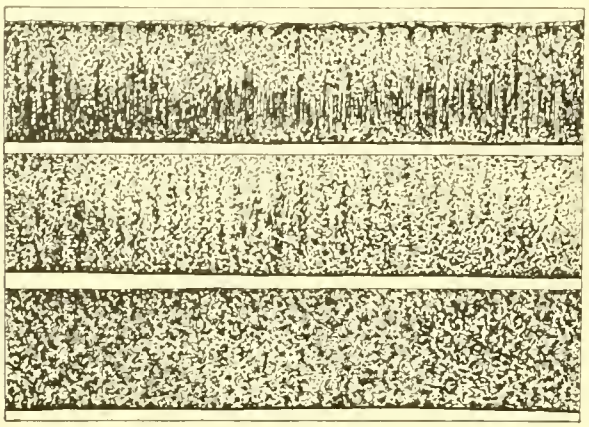


Fig. 10 Appearance of Cuts Made at Various Speeds

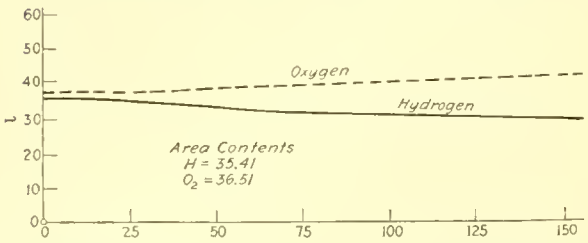


Fig. 11 Curves for Determining Quantities of Oxygen and Hydrogen (in liters) Corresponding to a Fall of Pressure of One Atmosphere at Certain Pressures.

to this rule and in order to prevent the rough edges due to the action of the oxygen jet it was necessary to cut at a comparatively high speed. Various precautions were taken to obtain reliable data for speed of cutting; thus the time of cutting was reckoned not from the edge of the plate, but always from the moment after 50 mm. (2 in.) of the cutting had been made. Further, in order to secure the same test conditions, the plate, after each cutting, was carefully cooled in water, since, as appeared later on, even a slight rise in temperature produced a remarkable difference in the speed of cutting and the consumption of oxygen. This cooling, especially in the case of thicker plate, took a great amount of time.

Determination of Gas Consumption. The consumption of oxygen was determined by the fall of pressure in the flask. Up to 20 atmospheres calculation was possible in accordance with the Boyle-Mariott law, since the weight of the contents of the flask was exactly proportional to the pressure, but at higher pressures there was a noticeable deviation from this law, as the author has determined by special tests made with oxygen and hydrogen. He found that the line of pressures for oxygen from 50 atmospheres up passed considerably below the PV-line, while for hydrogen it was considerably above it. These deviations are not constant and the hydrogen line shows a slight kink between 40 and 80 atmospheres, while the oxygen line is somewhat inflected between 60 and 100 atmospheres.

The author also made a control determination of the experimentally determined curve by analytical calculation in accordance with the Vander Waals equation

$$\left(p + \frac{a}{v^2} \right) (v - b) = 1 + \alpha t$$

for oxygen and hydrogen. He found that the curves derived from this equation coincided almost exactly with the experimental curves, the difference being such as was probably due to the inexactness of the manometers and errors in observation. By this means, it is possible to determine the gas consumption analytically from the known fall of pressure. This process, when a large number of readings is to be taken, is tedious and not very accurate; therefore another pair of curves, shown in Fig. 5, has been derived, which shows exactly how many liters of oxygen and hydrogen correspond at certain pressures to a fall of pressure of 1 atmosphere. These curves have been derived by differentiation from the curves obtained by measurement and shown in an illustration not reproduced here. They hold, however, only for flasks of the size indicated, and for flasks of different sizes require a proportional recalculation.

Steam Engineering

Utilization of Sources of Natural Steam in Tuscany (*L'utilisation pour la force motrice des sources de vapeur naturelle de la Toscane*, G. Espitallier. *Le Génie Civil*, vol. 64, no. 17, p. 331, February 21, 1914. 3 pp., 4 figs. *d*). There are in Italy a number of so-called *soffioni* (blowers) or sources of natural steam created by the volcanic activity underground. It happens that in the section of the country where these *soffioni* occur, viz., in the northern part of the Tuscany mountains, there are also a number of *lagoni*, lakes of hot water containing important percentages of boracic acid. About a hundred years ago a Frenchman, de Larderel, had the happy idea of capturing the sources of natural steam and using the heat thus obtained for the evaporation of the boracic acid solution and its concentration and treatment. From these beginnings rose the powerful "Società Boracifera di Larderello" of today, and the present article describes the modern boiler installation of the plant designed to be used in connection with a turbo-alternator aggregate. The difficulty which had to be overcome lay in the presence of sulphurous acid and solutions of boracic acid and ammonia in the natural steam, which, while causing no appreciable trouble in reciprocating engines, were considered to be highly undesirable in steam turbine operation where there is a much greater tendency towards deterioration of the metal. A special Prache and Bouillon boiler is therefore used, in which the natural steam generates a secondary steam from pure water, the pressure of the natural steam being 3.5 atmospheres, and of the secondary steam, 3 atmospheres. The article describes and illustrates the construction of this special boiler in detail.

Influence of Temperature of Superheat on Steam Consumption of Engines (*Influence de la température de surchauffe sur la consommation des machines à vapeur*, V. Kammerer. *Bulletin de la Société industrielle de Mulhouse*, vol. 83, no. 10, p. 815, December 1913. 34 pp., 7 figs. *t.t*). The influence of superheating on the steam consumption of engines has been investigated several times, both theoretically and experimentally; in particular by Witz, Délaporte, and Berner. But nearly all investigators have attached particular importance to the determination of the economy of superheated steam as compared with saturated. In practice, however, it often happens that an engine sold under a certain guarantee, is tested at temperatures not exactly like those stated in the guarantee conditions and in such cases it becomes necessary to use a certain correction factor so as to bring the test results in accordance with the conditions of the guarantee.

This correction factor expresses clearly the influence of the temperature of the steam on the steam consumption of the engine, all other conditions, such as admission and exhaust, pressure load, etc., being equal. In this case, the difference between superheated and saturated steam is of no interest whatever, as in most cases the engines are not designed to work with saturated steam at all. This question of the influence of temperature on steam consumption cannot at the present time be solved in any other way than by experiments, since we know that the economies obtained in practice with superheated steam differ materially from those which theoretical considerations lead one to expect. To solve this question without making special experiments, the author made a search in literature and in the files of the association for data of tests made on the same engines at different temperatures of steam, and he found such data for one single-cylinder engine, three single-cylinder straight-flow engines, eight two-cylinder engines and three three-cylinder engines, all condensing, and four engines without condensation—two single-cylinder and two two-cylinder. The article describes in detail the construction of these engines and the data of tests, from which the author drew his comparisons. Owing to lack of space, only the main conclusions arrived at in this investigation will be reported here.

The first and most important conclusion is that it is impossible to formulate a general rule which would apply to all engines or even to a certain group of engines, and would express the variation in consumption as a function of the temperature of steam. In general, the influence of temperature of steam is proportional to the consumption proper of the engine, i.e., inversely proportional to the efficiency of design. But these two magnitudes, viz., the temperature and consumption—are not as closely and definitely related as was previously believed. The author found, especially among two and three-cylinder engines, engines with approximately equal thermo-dynamic efficiencies in which superheat produced very different variations in consumption, which is quite natural since the influence of temperature on steam consumption depends on a number of factors, the action of which may either add itself or, on the contrary, compensate for each other. Among such factors are number of cylinders, degree of expansion, dimensions of cylinders, dimensions of clearances, speed, distribution, presence of a jacket, etc.

The tests of Vingotte indicate that in the same engine the influence of superheat on consumption varied from 9.5 to 5 grams per deg. cent. when the load went down from 300 to 100 h.p. But even if it is impossible to formulate a general rule, these tests indicate several facts of interest: for the larger number of condensing engines, consumption up to a temperature of about 300 deg. cent. (572 deg. fahr.) is strictly a linear function of the temperature, that is, it decreases in proportion to the increase of temperature. This proportion appears to continue even beyond 300 deg. cent. (572 deg. fahr.) for engines provided with a jacket of the small cylinder, while for those which are not so equipped, the advantage brought by the superheat begins to decrease when one passes the above limit of temperature down to a considerably lower value. This appears to remain constant until about 500 deg. cent. (932 deg. fahr.), the limit of temperature attainable in practice. In other words, the curves representing the consumption as a function of temperature for condensing engines provided with jackets are straight lines, while for engines without jackets, they are curves with more or less pronounced convexity directed toward the origin. Further, the beneficial influence of superheat on consumption appears to be stronger the less economical is the engine itself. Non-condensing engines, whether single or double expansion, are strongly affected by the superheat, even though the absence of a condenser would lead one to suppose that the loss by initial cooling would be less than in the condensing engine. However, here the number of tests available is not sufficient to indicate a certain average.

The original article reproduces a number of curves which were taken from the tests referred to and plotted by the author.

Unclean Steam (*Unreiner Dampf*, F. Dohne. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 6, p. 206, February 7, 1914. 5 pp., 5 figs. *ep*). The tendency to increase the output of stationary boilers led to the production of types known as high-duty boilers or inclined-tube boilers, which, in comparison with the usual kind of tubulous boilers, possess the advantage of better utilization of the available floor areas and produce far larger amounts of steam. Further, they can be started in a shorter time and more rapidly brought to a high output. But these advantages are, to a certain extent, counteracted by certain disadvantages: among others, their greater sensitiveness to troubles due to poor feedwater and their small water contents which may lead to troubles when the demand for steam is irregular.

In addition, there is present a danger that a part of the boiler water may be carried over to the superheater and piping, so that even in uniform operation, one has to count on wet steam, especially when the surface of evaporation is comparatively small. And when the load on the boiler is so large that the water circulation is affected, violent boiling in the upper drum may make it altogether impossible to obtain a regular steam supply. These critical limits of load form one of the distinctive characteristics of the various types of inclined tubular boilers.

Priming of boilers has been observed particularly often after the water became enriched with salts. A high salt content easily produces retardation of ebullition and foaming, with the result that large amounts of water are driven over into the superheater. If at the same time an overload occurs with varying demand for steam, and perhaps along with an oversupply of feedwater to the boiler, it may happen

that the amounts of water carried over into the superheater may be so large that the superheater may be unable to vaporize it, with resultant production of water hammer and possible destruction of machinery. Further, such violent ebullition of the water in the boiler easily opens the safety valves, which in itself involves a serious source of danger to the boiler attendants. But even when the water is carried over into the superheater in a less violent manner, one cannot rely upon the superheater as an auxiliary evaporator. It is not designed for evaporating water even under the most favorable conditions; that is, when it escapes from the upper drum and in mixture with steam. Here, however, the amounts of water are much larger, and could be evaporated in the superheater without injurious effects only if the feedwater is technically pure, i.e., when the additional water has been properly distilled in the evaporators. If, however, the feedwater is impure and is more or less mixed with undistilled water, even when chemical cleaning has been used, the water carried over from the boiler forms deposits in the superheaters which, in accordance with the nature of the feedwater, may consist of scale or deposits of salts (common salt or sodium sulphate). These deposits attach themselves to the tube walls and very seriously affect the heat transmission and, as a result, the strength of the metal in the pipes.

Experiments have shown that steam may carry particles of such deposits down into the machinery, unless they are previously caught, and in the machinery such foreign bodies produce injurious effects in many ways. For example, they cause a material wear on the nozzles and blades of steam turbines, while in the regulating elements and in the body of the turbine itself deposits are formed which finally greatly lower the output of the aggregate, apart from the injuries which may be caused by larger pieces carried into the turbine. In reciprocating engines these impurities produce extreme wear of the piston, piston rings and cylinder surfaces, and may also produce saponification of the lubricating oil and wear of the sliding parts. The following example cited by the author from practical experience may explain the above statement:

Several months after the installation of the plant shown in Fig. A, several superheater tubes connected with the boiler burst. The investigation showed that nearly all the superheater tubes have been annealed. The boiler had a heating area of approximately 416 qm. (4476 sq. ft.) and the superheater about 144 qm. (1550 sq. ft). Over the water chamber is an upper drum of about 1800 mm. (say 70 in.) in diameter and 7050 mm. (say 277 in.) jacket length. The headers of 216 tubes each of a diameter of 108/100.5 mm. (4.2/4 in.) and 5500 mm. (220 in.) long were inclined to each other at an angle of 15 deg. The feed-water was admitted into the upper drum having been previously passed through an evaporating apparatus. The steam was taken from the front part of the boiler through an outflow pipe into which was built a water separator tank. The boiler was designed for a normal load of 20 kg. per 1 qm. (4.1 lb. per sq. ft.) and for a maximum continuous output of 25 kg., while for a short time up to 30 kg. (6.17 lb. per sq. ft.) could be evaporated.

Steam was produced at 15 atmospheres pressure and superheat of 360 to 400 deg. cent. (680 to 752 deg. fahr.). The water space of the boiler is about 22.5 cbm.; the steam space about 9.2 cbm., and the surface of evaporation about

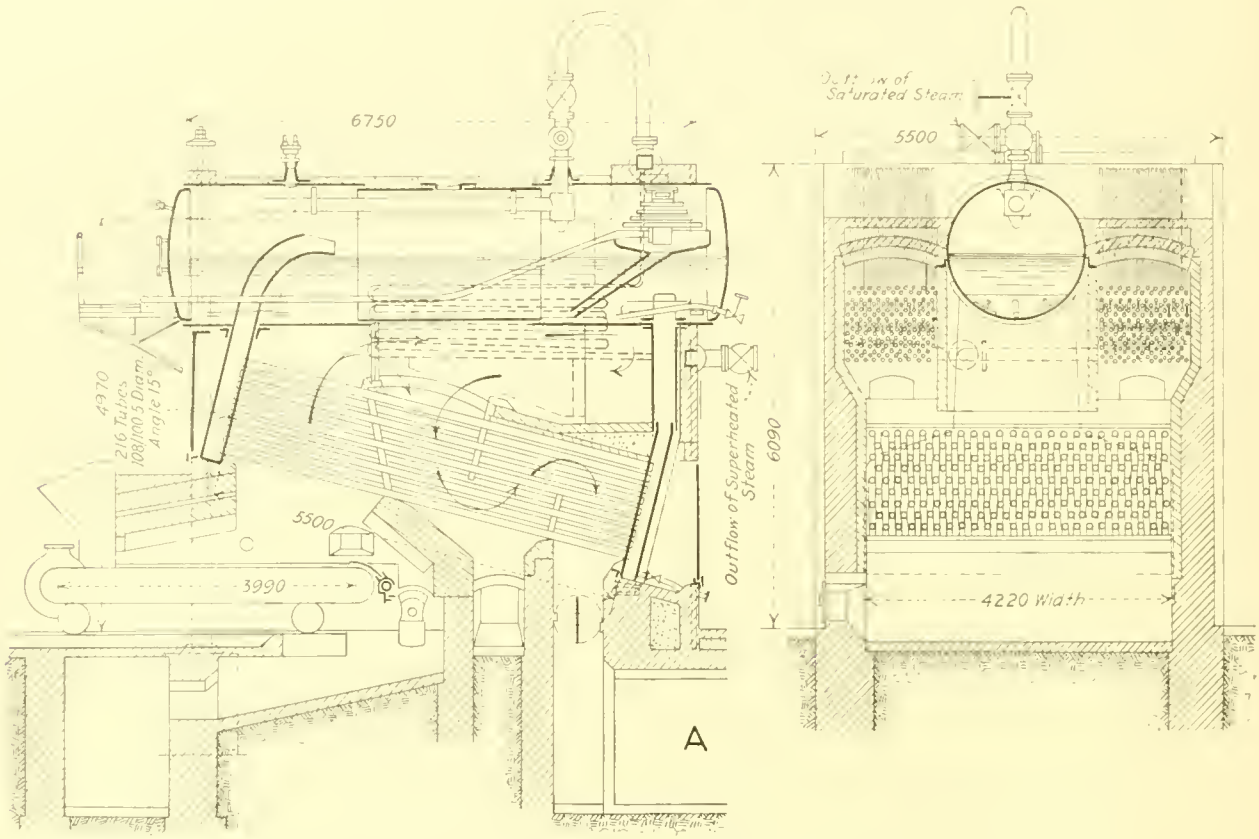


Fig. 12A Boiler Plant where Trouble was Experienced on Account of Unclean Steam: Initial Installation

13 qm. The load on the latter, with the demand from the boiler of 25 kg., is therefore approximately 800 kg. qm. (16.4 lb. per sq. ft.). The superheated tubes of 44.5/37 mm. in diameter are built in on both sides of the upper drum. For the admission of steam to and outflow from the superheater, collector chambers are provided located transversely over the entire width of the boiler. Each of the boilers is provided with a double chain grate on which coal dust up to 10 mm. (0.4 in.) grain and approximately 6000 WE (10,800 B.t.u. per lb.) heating volume is burned. A common flue gas preheater of about 720 qm. (7749 sq. ft.) is provided for all of the three boilers into which the feedwater, after it has been purified by the lime-soda process, enters with a temperature of about 90 deg. cent. (194 deg. fahr.).

During the investigation, the conditions of operation were unfavorable, as there were rapid and large variations in the amount of steam taken. This was not sufficiently well-known when the boilers were designed, so that special measures had not been taken to avoid the production of wet steam. A thorough investigation of the plant has shown that the largest part of the superheater tubes were coated on the inside with a hard crust, which was in the neighborhood of the entrance to the collector chamber approximately 2 mm. (0.08 in.) thick. Farther on, away from the upper drum, there was a heavy deposit of a gray color, practically filling up some of the pipes, and deposits were found all the way down to the water separator of the steam turbine; but while in the superheater proper they were hard and had the appearance of boiler scale; at the outlet from the superheater and in the live steam piping they were of less solid consistency. A noticeable difference was also observable in that the deposits in the superheater had no distinct taste, while in the collector chamber and adjoining pipes they had a salty taste. In order to explain the presence and nature of these deposits, careful analyses were made of the feedwater, and various kinds of deposits (the original article gives the analyses in detail); it was found that the deposits consisted mainly of sodium chloride, sodium sulphate, calcium chloride and manganese carbonate, or mainly of materials which could not have been evaporated together with the steam since none of them become volatile at the pressures and temperatures there available. All these deposits could have been carried over only with the water which has been taken up from the boiler into the superheater and piping by the steam.

It was of some interest to find out why the deposits in the two parts of the plant (the superheater and live steam piping) should have been of such a different nature, and the explanation appears to be as follows: When mechanically impure concentrated boiler feedwater was carried over with the steam, deposits were formed in which must have been present the elements of boiler scale formation (with a preeminence of calcium carbonate) and salts (common salt and sodium sulphate). Masses of this composition would first deposit in the superheater, while lighter and more soluble constituents of the scale would be subsequently washed out by boiling steam, which would carry them over into the live steam piping and deposit there. To remedy these conditions, in front of the superheater a special container, Fig. *B, C* and *D* has been installed, about 800 mm. (32 in.) in diameter and 5000 mm. (200 in.) long, in which the steam has a chance to free itself of the water and impurities. In addition, in the piping immediately in front of this auxiliary container, a water separator has been installed. The steam enters the container in the middle and leaves it from both ends.

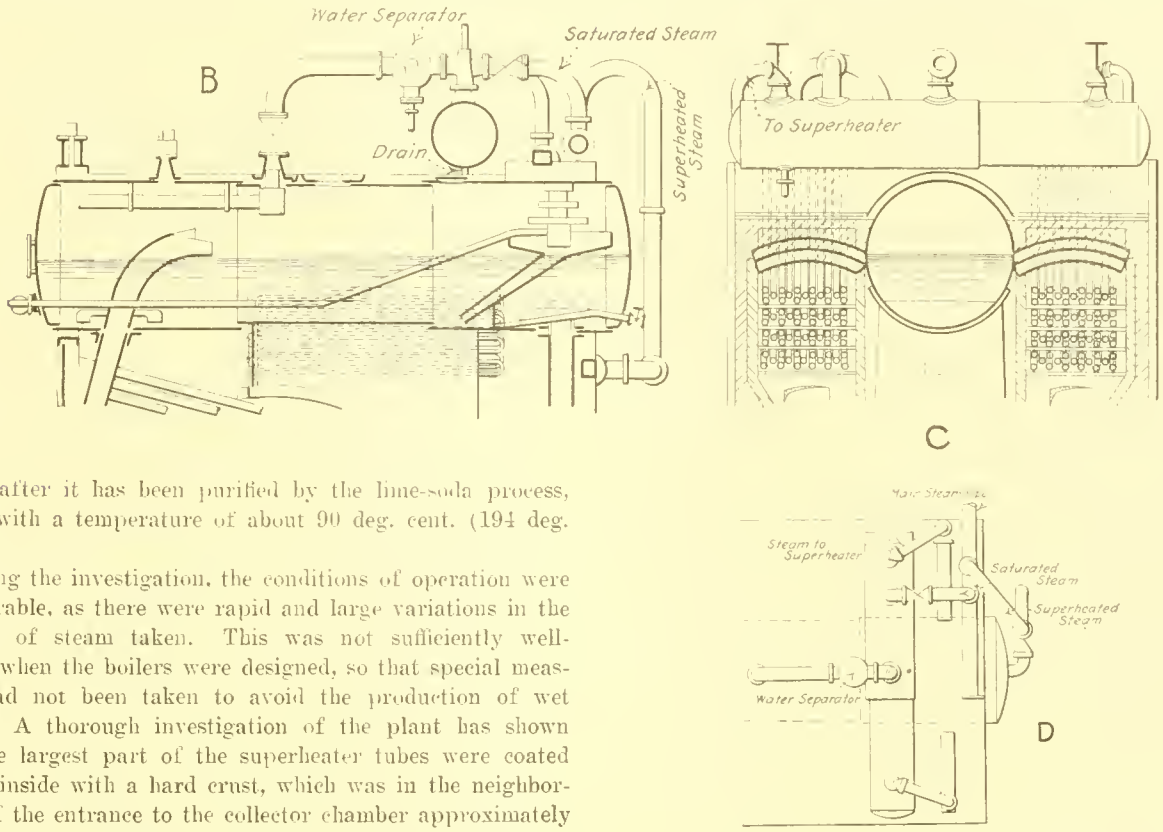


Fig. 12B, C, D Same Plant as in Fig. 12A: Improved Installation

In order to secure a uniform flow of steam through both halves of the superheater, the collector chamber has been divided as shown in Fig. C and D, in addition to which care has been exercised to daily blow off the boiler, letting the water off at frequent intervals to keep the salt content in the feedwater as low as possible, while at the same time, the steam demand system has been so modified as to prevent at least the most violent variations. Since then, the boilers have worked without trouble, with an average output of 25 kg. per 1 qm. (5.1 lb. per sq. ft.), and no trouble with the

bursting of superheated pipes has been experienced, although the feedwater remains the same as before and has been handled in the same manner as previously.

The article describes also a second case of a similar nature, where a reciprocating engine has been used.

As regards oil deposits in the reciprocating engine, attention may be called to the fact that often there is in them a considerable amount of iron oxide which may be explained by attacks on the iron of the boiler, superheaters or pipes. This is especially noticeable at high superheats, and may be intensified by the presence of caustic soda, which may be produced in the boiler from an excess of common soda. The iron oxide in combination with the deposits from the boiler water and lubricating oil forms practically insoluble deposits, which may often lead to ruptures in the machine's parts.

Strength of Materials and Materials of Construction

Arsenic in Rails (*Myshyak v relsakh*, A. I. Mitinski. *Journal of the Russian Metallurgical Society* (in Russian), no. 5, 1913, p. 650, 9 pp., *e*). The question of the presence of arsenic in rolled steel becomes of importance only occasionally, when it is initially present in pig iron (i. e. in the ore) since it is never intentionally introduced into the metal.

The Kerch ore, mined in the south of Russia, contains from 0.08 to 0.10 per cent arsenic; since the arsenic is oxydized somewhat more slowly than the iron itself, its percentage is practically unaffected by the metallurgical operations which the ore undergoes, though the absolute amount of arsenic present in the steel is somewhat reduced in the basic process. The author, together with Prof. A. A. Baykoff, made a thorough investigation of the influence of arsenic on rolled steel. The contents of arsenic have been intentionally increased by introducing metallic arsenic in boxes made of thin sheet iron into the ingot molds. The carbon contents were 0.35, 0.40 and 0.45 per cent, while the arsenic varied from 0.2 to 0.3 to 0.4 per cent. The temperatures were observed by the Wanner pyrometer; the strength of the test pieces measured by the impact test. The article gives full data of the tests, the present abstract containing only the main results.

It has been found that rails containing carbon in the neighborhood of 0.5 per cent exhibited great brittleness; this may have been due to the unusual high percentage of manganese which was as high as 1.09 to 1.17 per cent; rails with approximately 0.4 per cent carbon showed an evident increase of brittleness when the arsenic contents pass 0.25 per cent.

As regards simultaneous presence of phosphorus, it has been found that rails which contain the least amount of it prove to be the best of the group; this completely confirms the view that in order to eliminate brittleness in metal containing arsenic, the metal must be of low carbon and low phosphorus. From the tests made it does not appear that the presence of arsenic produces any apparent effect on the mechanical properties of the metal in so far as they are characterized by tensile tests. As regards macrostructure the introduction of arsenic causes a noticeable thickening of the ferrite lines. Further tests have shown that the increase of the arsenic content intensifies also the danger of rail breakages in very cold weather. They have likewise shown that manganese in large quantities is good only in very low-carbon steel. On the whole, the tests have shown that arsenic in quantities up to 0.25, or even 0.3 per cent in rail steel cannot be considered as absolutely inadmissible, but the steel must be dephosphorized as much as possible, and should contain as little carbon as possible, a low manganese content also being advisable under such conditions, although generally a comparatively high manganese content might do no harm.

As regards rolling, the arsenic rails have not exhibited any peculiarities.

Museums of Social Engineering in Germany and Abroad (*Die Sozialtechnischen Museen im In- und Auslande*, K. Hartmann. *Verhandlungen des Vereines zur Beförderung des Gewerbefleisses*, no. 1, January 1914, p. 65. Serial article, not finished, *d*). The article describes briefly the importance of museums, with relation to what the Germans calls "Social Engineering," both in Germany and abroad. A somewhat fuller description is given of the museums in Charlottenbourg and Munich.

ENGINEERING SOCIETIES

AMERICAN CHEMICAL SOCIETY

Journal, vol. 34, no. 3, March 1914, Easton, Pa.

The Compressibility of Ice, Theodore W. Richards and Clarence L. Speyers (4 pp., 1 fig. *e*). The investigation was conducted during the year 1909 and a preliminary report giving the results but no details was published in the year book of the Carnegie Institute of Washington for 1910. The present publication gives complete detail of the methods used, a summary of the investigation being presented by Mr. Richards (C. L. Speyers is dead), as follows:

The compressibility of ice between 100 and 500 megabars is found to be 0.0000120 at —7.03 deg. cent., or about one-quarter of the compressibility of water at neighboring temperatures. It is found not to decrease remarkably as the pressure increases. This is probably the first direct determination of the compressibility of common ice which has ever been made. The difference between the low result and the higher value obtained by Bridgman through indirect calculation is probably due, at least in part, to the existence of a large temperature coefficient.

AMERICAN PEAT SOCIETY

Journal, Vol. 6, no. 4, October 1913, Toledo, Ohio

Practical Peat Utilization, John N. Hoff
Peat Powder as Fuel for Locomotives (Abstracted)

Peat Powder as Fuel for Locomotives (1 p. *d*). It has recently been announced that von Porat, a Swedish engineer, has perfected a process for utilizing peat powder as fuel for locomotives. The powder is manufactured by the Ekelund process which, in itself, does not appear to have made much headway as yet. In the von Porat system the peat powder is fed by an automatic process into the furnace of the locomotive, and it is claimed that substantially the same results can be obtained from 1½ tons of peat powder as from 1 ton of coal. The powder may be burned with admixture of about 5 per cent of coal. No change has been made in the boiler or fire-box except the installation of special apparatus, the powder passing from the tender to the fire-box through a conveyor pipe. No cold air is allowed to enter the fire-box.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Proceedings, vol. 40, no. 2, February 1914, New York

An Investigation of Sand-Clay Mixtures for Road Surfacing, John C. Koch
Report on a Series of Tests on Concrete Columns Reinforced with a Spiral of Steel, C. G. Wrentmore, Hugh Brodie, and C. O. Carey (Abstracted)

REPORT ON A SERIES OF TESTS ON CONCRETE COLUMNS REINFORCED WITH A SPIRAL OF STEEL, C. G. Wrentmore, Hugh Brodie and C. O. Carey. (Paper read March 18, 1914, 43 pp., 18 figs. *et.l*). The tests described in this report were made in an effort to design columns of reinforced concrete even though low stresses and excessive quantity of material might be required to insure safety. Experiments on the ultimate strength of columns with longitudinal steel bars imbedded in the concrete indicate that such reinforcement, unless hooped or banded at frequent intervals, could not be relied upon to increase the strength of the column, and in some cases might even render its strength less. The present tests were planned to determine the longitudinal and lateral deformations of the columns under various loads, increasing from zero to something above the probable maximum working strength with varying quantities of reinforcement and at different ages; also the ultimate strength and the load at the first visible sign of failure. From the deformation was to be determined the change in unit length for the various loads, the modulus of elasticity and Poisson's ratio with an idea that comparison of the results should show the influence of the reinforcements on these several quantities.

The spirals of steel were put on in two ways. In some cases they were wound on the concrete shaft after casting by placing the column in a lathe and winding the wire on under constant tension sufficient to bed it slightly in the concrete. This was done just before testing at the age of 28 days, the end of the wire being anchored securely in the column very near the winding end, the tension then applied and a dozen turns wound on as close as they would lie in order to insure against failure at the end; the spiral was then spaced by using the lathe screw until within 1 inch of the other end; then another dozen turns were run on close together. In the remaining columns the spirals were made up and set in place in the form and the concrete was then poured. The longitudinal bars of the reinforcement were barely sufficient to hold the spiral in place. There were strips of No. 24 gage galvanized iron 7/16-in. wide and notches 7/32-in. deep, accurately spaced by machine. The consecutive turns of the spiral were dropped into these notches and fastened by pinching down the lugs formed in cutting the notches. Four such spacing strips were used for each coil, and as they were so light, considerable care was necessary to insure the proper location of the reinforcement.

The article gives in considerable detail the methods of test determination of extensometer constancy; computation of values and test data cannot all be tabulated owing to a lack of space. The conclusion to which the writers come are as follows: (1) The value of Poisson's ratio is approximately 8 for short-time and 7 for long-time tests. (2) The value of e is in general below 10, only exceeding that value for short time and high stress. (3) Spiral reinforcement does not, by its restraining effect on the core, perceptibly affect the values of m or e for stresses below 900 lb. per sq. in. (4) Spiral reinforcement does not perceptibly assist the concrete in carrying the load within the limits of ordinary working stresses. (5) The limit at which the first visible sign of failure occurs is raised by spiral reinforcement; this effect is greatest in short-time tests, and is perceptible for all percentages of reinforcement. (6) The plain column fails abruptly, giving no warning of approaching collapse; the hooped column may be depended on to give warning of approaching failure at from 70 to 90 per cent of the ultimate strength, when not less than 0.50 per cent of steel is used. (7) The deformation is quite irregular up to about 400 lb. per sq. in.; above this it is quite regular up to a limit which is not defined by these tests, but is well above allowable working stresses.

The tests indicate, but cannot be said to prove conclusively, that:

(8) The ultimate strength of the column is increased by spiral reinforcement by an amount roughly proportional to the quantity of steel used, up to the limit of 1.58 per cent; and above this limit the ultimate strength is simply the amount which can be carried by the granular core supported by the spiral, but with no cohesion of its own.

ASSOCIATION OF ENGINEERING SOCIETIES

Journal, vol. 52, no. 2, February 1914, St. Louis, Mo.

The Status and Duty of the Engineer, J. A. Ockerson
Recent Economies in the Sugar Industry, A. L. Webre (Abstracted)
Railroading Sixty Years Ago, C. D. Purdon

RECENT ECONOMIES IN THE SUGAR INDUSTRY, Alfred L. Webre (17 pp., 11 figs. *dh*). New conditions brought about in the sugar industry by reason of the recent tariff changes make it imperative to produce sugar more cheaply than was previously done. One of the possible economies lies in a better system of steam utilization. In a sugar factory steam is used for various purposes: it supplies energy for the operation of machinery; it is used to heat the juices from about 60 deg. to 212 deg. fahr.; in the multiple effects and in the vacuum pans. The amount of energy taken up for power purposes is small as compared with the total energy consumed, and the introduction of more economical engines, such as compound condensing instead of simple, Diesel engines or electric generators driven by steam turbines, would not bring about as great economy as might be expected, and in some directions the more economical engine might even involve heat losses. Thus the steam used in a compound condensing engine is not available for evaporation purposes, and would give up only a part of its mechanical energy, while the remainder would be absorbed in the condenser.

Under the conditions existing at present in American sugar factories where furnaces burning bagasse may be considered to give good results, the problem with which the sugar steam engineer is confronted is not power economy but heat economy, and to get over-all results he must consider not the power plant but the heating and evaporating apparatus. The present Louisiana practice in this regard is not up to the standards of Europe and other countries. There is only one Louisiana house having vapor heaters in successful operation; only two houses equipped with quadruple effects, though there are a great many triples. The majority have plain doubles and quite a number have no effects at all, using open evaporation throughout. All these will probably have to be changed to meet the present modified conditions. In Europe there has been a general devel-

opment, which the author describes in detail, to approach the complete utilization of the heat developed. He shows the gradual evolution of multiple effects. It was found in Europe that when a quadruple was operated in the manner described, there was not sufficient exhaust to do the work, but it paid better to put live steam in the first body than in the pans and heaters, as each pound of steam used in this way did several times as much work as by the old methods. A further experiment was, instead of putting live steam at 100 lb. pressure in the first steam belt, to put it into the Pauly pre-evaporator and boil the juices before permitting the steam to reach the effect under 8 lb. pressure, which involved great advantages. In fact it was found that such an apparatus did 25 to 30 per cent more work than a plain quadruple with the same steam. In addition, the vacuum in the last effect was not allowed to exceed 24 in., thus requiring less condensing water and fewer pumps. However, inasmuch as the third and fourth body operating on vapors from the preceding units after these have been robbed for the heater and the pans could do only very little work, it appeared logical to eliminate the condenser altogether, and to operate the last body atmospheric. This has been successfully accomplished under limited conditions in the Kestner effect, where it was made possible because of the high efficiency of its heating surfaces as compared with the ordinary apparatus.

The author explains in detail why it was so difficult to attain this end and what objections may be raised to the arrangement. He further shows that with this equipment, it is possible to operate a 1000-ton Louisiana house on approximately 1000 h.p., as compared with 1825 h.p. required when the ordinary double effect is used, 1480 h.p. with the triple effect and 1300 h.p. with the quadruple effect. The author believes therefore that the house equipped with an atmospheric double, a vapor heater and vapor pan will operate on bagasse alone continuously and have fuel to spare. He describes and illustrates the apparatus recommended, and gives data of tests in the form of both tables and curves.

CANADIAN SOCIETY OF CIVIL ENGINEERS

Advance proof

Bridge Substructures built by the Pneumatic Method, John W. Doty. The purpose of the paper is to give a few examples of sub-structure work, constructed by pneumatic methods in Canada during the last few years, and the reason for the adoption of this method in each case. It briefly describes the use of this method on the following bridge substructures: Two bridges over the Red River at Winnipeg, bridge over the St. Lawrence River near Lachine, over the Harrison River at Harrison Mills, B. C., over the St. Lawrence River near Quebec, and over Mud Lake, near Perth, Ontario. The conclusion to which the author comes is that, under certain conditions, the pneumatic method, although the most expensive one in the general classification of foundations, is also, for the given conditions, the most economical and gives a certainty of securing a suitable footing beyond any doubt, as well as insuring the speed of completion and the positive manner in which difficulties can be overcome.

CENTRAL RAILWAY CLUB

Official Proceedings, vol. 22, no. 1, January 1914, New York

Air Brakes: Why Their Possible Utility and Performance is Not Obtained in a Higher Degree in Actual Service, Walter V. Turner (52 pp. *gpl*). Only a few points of this interesting paper can be reported here. The author, chief engineer of the Westinghouse Air Brake Company, calls attention to the fact that while a design of an air brake is a mechanical proposition, its possible utility and performances in actual service might also to a very large extent be called a problem in psychology, the human equation being an important element in the proper performance of a brake. Further, the brake may be properly divided into two parts, viz., the air operated device and the foundation brake gear, the latter comprising all of the parts affected by the operation of the brake piston, i.e., the rods, levers, shoes and truck. These, and not the air operated mechanism itself, are the variables, for it is upon these that comes the consequent wear and tear. While it may be assuming too much to expect that the car be built around the brake installation, as a matter of fact if proper economy, efficiency and safety are to be insured, this is as it should be. The truck and cars should be designed in such a manner as to include all the provisions necessary for a proper brake and its installation.

There are four factors which contribute to the result of the operation of the brake, viz., the time, the braking ratio of the design, the overall efficiency of the foundation brake gear, and the speed. (It is unreasonable, as the author shows in detail, to expect a desired stop from an arbitrarily fixed percentage of brake ratio.) The manufacturer of air actuated devices controls only one of this four, viz., the time element, and this in itself cannot be made to compensate for shortcomings in the others. The author shows by curves how the operation is affected by deviations in cylinder pressure, which in turn determines the retardation of the car, and as a consequence its relation in this respect to other cars in the train. He discusses in detail the factors affecting brake design, conditions affecting brake operation and gives some advance information on the *electro-pneumatic brake*. As regards the factors affecting brake design, he indicates eight functional relations between various magnitudes of the car, and shows that any one of these eight values can be included among what he has previously called the fundamental requirements; and further, and even more important, any one of them can be arbitrarily chosen.

The author comes, therefore, to the conclusion that the practical brake must be a harmonious, consistent whole, embracing both the brake apparatus and the entire car design.

ENGINEERS' CLUB OF PHILADELPHIA

Proceedings, vol. 31, no. 8, January 1914, Philadelphia

The Limitations of Mathematical Theory Applied to Engineering, W. G. Button (abstracted)
Colossal Waste Due to Bad Municipal Engineering, Bernard J. Newman
The Hudson River Crossing of the Catskill Aqueduct, Ralph N. Wheeler
Concrete Roadways, Lewis R. Ferguson

The Limitations of Mathematical Theory as Applied to Engineering, W. G. Button (16 pp., 5 figs. *tg*). The author proposes to point out some of the necessary limitations of mathematics as applied to engineering construction. The author discusses from this point of view the question of stresses in columns, framed structures, domes, arches, retaining walls, and steel base slabs. The section on steel follows herewith:

Steel to the layman is a hard, dense material of prac-

tically unlimited strength. To the man of science it is first a crystalline aggregate, crystals of perlite, martensite, hardenite, etc., held together by cementite, or a mixture of cementite with uncombined graphite. These crystals, which are beautifully shown by polishing and etching, vary in size and shape, and furthermore are very susceptible to thermic changes, affecting materially the strength of steel. They are held together by their own innate cohesive force, of which very little is known; and fracture may occur by sliding on their cleavage planes, thus splitting into smaller crystals. These lines of displacement can often be clearly seen on the etched surface, or the failure may occur in the cementing material, the crystals separating, and this is perhaps the more unusual procedure.

Going a step further into the constitution of steel, it is found that the crystals are composed of more or less complex molecules, which in turn are but solar systems of atoms, almost infinitesimal spheres separated from each other by relatively large distances, and moving at incomprehensible velocities. The division of matter is now carried still further and we must imagine the atom as made up very much smaller corpuscles, and these are possibly only vortex rings in the ether, like smoke rings in the air, which mathematically are said to be the equivalent of a solid. We will stop, however, with the molecule as being the physical unit. These molecules are interpenetrated by an imponderable substance of such apparently contradictory qualities as to be practically inconceivable of almost infinite elasticity, of a density far greater than steel, but at the same time so tenuous that they offer scarcely appreciable resistance to the motions of the heavenly bodies. Matter, however, is only a sieve with very wide meshes.

Matter is made up of atoms separated by relatively large distances, while the generally accepted idea of the other is that it is a continuum. This will enable us to get the idea of its density. Steel is porous; the density that we measure is only that of particles diffused through this ether. If we knew the density of an atom of any element we could by means of the combining numbers calculate that of an atom or molecule of steel. *The ether is the only really rigid body in the universe.* Fundamentally all molar stresses in matter resolve themselves into molecular stresses, and these are probably stresses or strains in the universal liminiferous ether. The simplest reaction of a beam on a column is to be explained rationally only by the intermolecular forces.

INSTITUTE OF MARINE ENGINEERS

Transactions, vol. 25, February 1914, Stratford

The Upkeep and Management of Boilers on a Tramp Steamer, G. A. O'Neill (Abstracted)

Report on the Circumstances attending an Explosion at an Electricity Generating Plant

The Upkeep and Management of Boilers on a Tramp Steamer, G. A. O'Neill (22 pp. *p*). A discussion of practical methods of the upkeep and management of boilers on a tramp steamer, and among other things, attention is called to external corrosion of boilers. On the bottoms of combustion chambers on the fire side an incrustation of scale and dirt will form, if not carefully watched, and with the combustion chamber frequently swept and scraped out, this scale obtains quite a smooth surface and appears like the plate itself. However, it can easily be detected by tapping with the round end of a hand hammer, when it will break off in flakes. If the scale is allowed to form, corrosion invariably goes on underneath it and the thickness of the plate is sometimes seriously reduced before it is noticed. Salt from leaky tubes and joints, when mixed with wet ashes, causes corrosion, and as this often occurs in the combustion chamber, it is essential to stop the least noticeable leakages as soon as possible. The boiler front end plates at the bottom suffer a great deal from contact with wet ashes.

In the discussion which followed, Jas. S. Gander stated that, so far as he had observed, this furnace corrosion did not occur when the boilers were fitted for burning oil fuel, since the whole circle of the furnace was generally used for heating surface. External corrosion from the fire side is also absent with oil fuel, as the heating surface could be kept much cleaner. He claimed important advantages from the careful use of calcinated soda: on one occasion he had been obliged to run a donkey boiler for a week on sea water, not even having the benefit of the condensed feedwater which was put into the main boilers. Soda was constantly used and attention paid to the scumming and drawing off of sediment. Upon opening up, the heavier scale found was less than 1/16 in. thick on the crown of the furnace, the other parts being practically clean. On the same vessel, with the same precautions used, the main boilers ran from February to the end of September, water being unchanged, and on opening up practically no scale was found.

James Shanks spoke about the extreme care which should be observed when circulating the water with steam pressure on the boiler. A number of engineers had been attempting to get some automatic system of circulation both for raising steam and under banked fires, but there did not appear to be any which was quite efficient. Some do excellent work while lying under banked fires, which was important in tramp steamers and should be fitted into every ship, as any engineer would hesitate in using a donkey or feed pump for circulation with a pressure of 220 lb. on the boiler. There was always danger, and some automatic system of circulating water under banked fires was needed.

INSTITUTION OF ELECTRICAL ENGINEERS

Journal, vol. 52, no. 227, February 2, 1914, London

Electric Train Lighting Systems, T. Ferguson (13 pp., 15 figs. *cd*). The author gives a general description of the British and some continental makes of electric train lighting equipment. In conclusion he gives a table reproduced here as Table 3, Page 095.

INSTITUTION OF MECHANICAL ENGINEERS

Advance copies of dates indicated, London

Some Modern Methods of Welding, Thomas T. Heaton (abstracted)

Water as A Mechanical Agent, Edward B. Ellington (abstracted)

Some Modern Methods of Welding, Thomas T. Heaton. (advance publication *C*, paper read February 20, 1914. 15 pp., 18 figs. *cd*). Broadly, the modern methods of welding may be divided into electric welding and gas welding. In electric welding, the chief systems are as follows:

The electric arc system, in which the best known representatives appear to be the Benardos system and the Zerener process: The Benardos system uses a direct current of about 90 volts and an amperage depending upon the thickness to be welded; in ordinary products running from 200 to 500

amperes. The work itself forms the positive pole of the arc and a carbon rod the negative pole, this arrangement being used so as to secure the greatest amount of heat in welding, as the positive pole is the hotter. The arcs are arranged in parallel, and provided with a regulator to adjust the current to the work done. In the Zerener process, there are two carbons in the same holder and a magnet which deflects the arc produced between these two carbons, downward onto the work. No current passes through the work at all.

The Strohmenger-Slaughter system may be used with either direct or alternating current. The parts to be welded are placed in juxtaposition; an electrode is laid upon and along the welding line; contact is then made between the work and one end of the electrode, which fuses by a series of arcs along the welding line, melting the electrode and coating the weld with a vitreous flux. It is claimed that this flux prevents oxidation.

Electric contact welding is done by machinery. In the Thompson-Houston process, which is a good representative of that class, the pieces to be welded are fixed in the machine, one immovable and the other in a slide rest. The piece in the movable slide is pressed by means of a screw against the other and a very heavy alternating current is passed through. The electric resistance of the joint causes a rise of temperature to welding heat and the movable piece is pressed forward until the complete union is made. The voltage is very low (from 2 to 4 volts). The current is about 16000 to 20000 amperes per sq. in.

Another method of contact welding differentiates between spot welding and roller welding. In the first, the work is upon a fixed copper contact piece and a second movable electrode is pressed upon it immediately above the fixed electrode. The current, in passing from one electrode to the other, heats and welds the work. In roller welding, electrodes are rolls which grip the work overlapped between them, heating and welding it as it travels. This system requires a good quality of metal, homogeneous and free from scale or dirt, and necessitates a somewhat delicate adjustment of the time and current; but it can produce remarkably good results in welding.

In gas welding, the best gas to use is acetylene or benzol vapor; coal gas and hydrogen have also been successfully used in conjunction with oxygen.

The author discusses in detail the strength of welded seams.

Water as a Mechanical Agent, Edward B. Ellington. (Thomas Hawksley Lecture, delivered December 5, 1913. Advance copy B, 17 pp. *g*). This is the first lecture in a series established by the council of the Institution of Mechanical Engineers in memory of their distinguished past-president, an engineer of unusual achievement and great influence in the development of hydraulic gas and drainage machinery in Great Britain and elsewhere. The speaker gave a brief biography of Mr. Thomas Hawksley, and indicated in general the development of hydraulic engineering in its various branches during the last hundred years.

INSTITUTION OF MINING ENGINEERS

Transactions, vol. 46, part 3, 1914, London

The Absorption of Oxygen by Coal, T. F. Winmill (Pt. 1., 15 pp. *epA*). The results obtained in this important investigation are presented here in abstract, the reader being referred to the original article for the detailed data and tables. So far four sets of experiments have been carried out: (*a*) on the relative rates of oxidation in the various parts of the Barnsley seam; (*b*) on the effect on the rate of oxidation of reducing the oxygen content in the intake air; (*c*) on the effect of the size of the coal-dust particles on the rate of oxidation; (*d*) on the effect of temperature on the rate of oxidation.

As regards the relative rates of oxidation of the various parts of the Barnsley seam, the rates of oxidation of the various substances occurring in the seam (hard coal, soft coal, cannel coal, jacks, shale and mother of coal) have been determined at 30 deg. cent., which temperature appeared to be somewhere near a normally cool goaf temperature for the mine from which the samples were taken. The curves plotted from the results obtained show clearly, first the very rapid oxidation which takes place during the first few hours in freshly cut coal and, secondly, the fact that this is followed by a much slower absorption which persists for a long time, the results for different parts of the seam being quite similar. The amount of oxygen absorbed is roughly proportional to the content of carbonaceous matter in each substance. The mathematical analyses of these curves show that each represents with a fair degree of accuracy the sum of two chemical reactions obeying equations

$$\mathrm{Log}_e \frac{A_1}{X_1} = K_1 T \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

$$\mathrm{Log}_e \frac{A_2}{X_2} = K_2 T \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

where A_1, A_2, K_1 and K_2 are constants, and X_1 and X_2 are the rates of absorption of oxygen in each of the substances respectively at a time T. There are here apparently two reactions, one starting with the rate of absorption of A_1 cu. c. per 100 grams of coal per hour, which falls to half in about 6 hours, and the other at A_2 cu. c. per 100 grams per hour, which falls to half in about 100 hours. The values of A_1 and A_2 represent the rate of absorption at the beginning of the experiment and the sum of A_1 and A_2 should therefore be a little greater than the first numbers in each of the corresponding tables. As a matter of fact they are less, owing to several causes. With the above equations it is possible to calculate the amount of oxygen which the coal will absorb from the beginning of the experiment to the time when it will absorb no more, and it appears that the main influence on the actual firing of the coal is due to the second reaction.

A further point of interest which is brought out by the analysis of the air which passes through the coal is the small amount of carbon dioxide that is produced in the oxidation. From the hard coal, at 30 deg. cent., less than 20 cu. c. of carbon dioxide is formed during the absorption of 760 cu. c. of oxygen.

Combustible Gases evolved during the Oxidation of Coal. At 30 deg. cent., there seems to be no carbon monoxide produced in the presence of free oxygen and the combustible gases consist, first, of methane, and later small quantities of higher hydrocarbons. The total amount of combustible gases given off by 100 grams of each substance during oxidation varies from 37 cu. c. for hard coal to 80 cu. c. for soft coal. To obtain some idea of the effect of the partial pressure of the oxygen on the rate of absorption, the intake of pure atmospheric air was replaced by a reservoir delivering at constant pressure air containing 8.28 per cent of oxygen. The coal used for the experiment was the "hards." The

absorption rate was far greater than it would have been if it were proportional to the particular pressure of the oxygen, and shows that any proposal to stop at any rate the earlier stages of spontaneous heating by a reduction in the percentage of oxygen short of the total removal of the oxygen would appear to have no basis in fact.

Effect of Fineness of Dust. In all the experiments described so far, the dust was ground to pass through a 200-mesh sieve, but further experiments were also made with dust passing through a 10-mesh and left on a 30-mesh sieve, and with dust passing through a 30-mesh and left on a 60-mesh sieve. It was found that the rate of oxidation is not simply inversely proportional to the size of the particles, which may be due to the fact that the coal is porous and the oxygen is therefore able to penetrate into the interior of each particle.

Effect of Temperature on Rate of Oxidation. After some oxygen has been absorbed, the temperature of the coal will rise and a new rate of absorption will commence. To understand how the coal goes on heating until it ultimately fires, the temperature coefficient of the rate must be known. The experiments on the variation of the rate of oxidation with temperature are not yet concluded, but what has been done indicates that this rate increases greatly with the increase of temperature. A second paper by the same author on the same subject is in course of preparation.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Some Experiences in Reversing the Main Air Currents in Coal Mines and the Mechanical Structures Involved. W. Clifford (2 pp., 10 figs. *dp*). The account in this paper is taken from the Iron and Coal Trades Review for February 13, 1914, as the original publication of the Society is not yet available.

The author describes various appliances for use in reversing the amount of air currents, the paper being based mainly on United States practice. He shows and illustrates the reversing doors designed by himself, which permit of the retention of the lines of Guibal's évasée chimney, and at the same time provides doors of sufficient length to close the chimney opening for reversal, and, by controlling the limits of their upward path, to do away with the risk of striking the revolving fan blades. He also described reversible exhaust and blow fans of various types and showed a method of reversing the main air current independently of the fan.

In the discussion that followed, Percy L. Wood stated that in England it was thought that there was a good deal of danger in reversing the ventilation. He suggested that in the case of a fire in the down-cast shaft, if a blow fan were suddenly converted into an exhaust fan there would be danger in a fiery mine. Assuming the goaves held gas when the fan was converted from a blower into an exhauster, and a large amount of pressure was taken from the workings, the gas would naturally be emitted in considerable volumes and would be drawn over the fire with probably disastrous results. On the other hand, if the exhaust fans were suddenly reversed, there would not be anything like the same danger because whatever gas happened to be in the goaf would probably be sent further into the goaf. As regards the necessity of évasée shape of outlet, the speaker made some experiments without such shapes; they reversed in something like 30 seconds and had nearly as much air in the reverse direction as in the proper direction.

Charles Pilkington stated that in England they do not want to reverse the air very often nor to have the reverse current as large as the ordinary current; all they wanted was to have a certain amount of reverse current down the pit. It was the law of the land to have the fans so constructed that they would reverse the current and not that they *must* reverse it.

NEW ENGLAND RAILROAD CLUB

February 10, 1914, Boston

Steel Passenger Cars, F. M. Brinkerhoff (33 pp., 8 figs. *dg*). The author believes that the use of steel cars will not reduce the number of accidents, but may mitigate the injury to passengers and cars when the accident does occur. Large sums, however, are involved not only in the first cost of the cars, but in the operating expenses as affected by the weight of the car, and relative cost of maintenance and repair of the various types of car body structure, so that a very thorough investigation of these questions, not only under normal conditions but also when subjected to the test of derailment or collision, becomes important. The question of weight is of great importance. A steel passenger car, properly maintained and repainted at suitable intervals, should be serviceable for from 30 to 40 years. Now assuming that the cost of power for hauling one pound of car weight per year averages $0.01 and in rapid transit service $0.05, it is obvious that $20 per year per ton for 30 to 40 years is a pretty heavy penalty for accepting a hasty or undeveloped design involving unnecessary weight. On the other hand, a saving in weight must not be made to the detriment of the maintenance cost. The design must therefore combine, to as great an extent as possible, the following essential features: (*a*) The safety and comfort of passengers; (*b*) low cost of operation; (*c*) low cost of maintenance; (*d*) moderate first cost.

In consideration of safety, not only should the capacity of the car body structure to resist collision and derailment shocks be regarded, but coöperation with the claim department may disclose many little details of finish, hardware, clearances, etc., which may have caused personal injury in the past and which can easily be avoided in a new car design.

Except in cars of a special type or cars constructed with blind ends wherein the end sill is also the buffing sill, all shock of collision impact will be received by the center sills through the medium of the draft gear and the buffing device. It is manifestly of the utmost importance to secure center sills against buckling in any direction, due to shock or load applied to the buffing sills, either in a longitudinal or vertical plane. It is usual to assume that a given shock is divided between the buffing device and draft gear in a definite proportion, but frequently heavy shocks are delivered against a closed knuckle, in which case the loading of the center sills as above assumed is not realized and the shock may produce buckling of the sills unless the draft gear should fail first, in which case the shock will be transferred to the buffing device. Also the entire sills forward of the truck may buckle in an upward direction. In order, therefore, to avoid excessive weight of the deep center sill construction necessary to meet the above described eccentric loading, it is advisable to support and align the center sills against deflection by means of suitable cross-bearers and body end sills attached to the side frames and center sills.

In this manner the center sills will be relieved of all deflection due to live or dead load and their full sections will be available to transmit longitudinal shock.

The author believes that the calculation for strength of center sill to resist end shock should be supplemented by investigation of its ability to support the car whenever, for example, the buffing sill of one car in collision over-rides the buffing sill of another car and the train has been derailed leaving the center sill unsupported at the center plate. As regards permissible weight, a consistently designed steel coach should weigh less than a wooden coach of the same dimensions and be materially stronger. As regards the type of framing, the author believes that it is essential that ample section be used in the center sill construction, to withstand the expected strains, but by the use of adequate cross-bearers, well connected to sills and side frames, it will be found possible to design suitable center sills of practically uniform section for their entire length and thus effect a great economy in weight as compared with fish-belly center sills frequently used in passenger car construction. The body end sill, with its cover plate connections, should be designed to transmit all vertical loads from the center sills to the side frames supporting and aligning the center sills against deflection in any direction. An unobstructed underframing is particularly desirable for the application and inspection of equipment; it is also desirable to utilize the entire side of the car as a truss or girder with the side as a top member instead of using the plate rail as the top member of the girder formed by the side below the windows.

In steel cars it is entirely practical to proportion and reinforce the inner piers so that very effective truss construction can be obtained. A carefully designed roof can add greatly to the ultimate shock resistance of a car structure, the side decks acting virtually as flanges for the tops, and the side frames will preserve its alignment and prevent the separating of the side plates and posts. The roof construction can also be made to afford a considerable element of safety on occasions when the car may be derailed on an embankment or bridge and overturned.

The author further recommends the elimination of joints, especially such as may be attacked by corrosion. He believes that a sleeping car weighing about 125,000 lb. complete could be designed. It is seldom that the failure of the underframe is the cause of injuries to passengers in cases of derailment or collision, but rather the inadequacy of the upper body; a redistribution of the strength members might therefore result in producing a structure offering a maximum protection to passengers with a somewhat reduced weight. As the center sill is usually the heaviest single part in the car, its permissible weight is of great importance and may be minimized by relieving it of all vertical load, so that its cross-bearing connections to high side frames which when designed in the form of a truss have ample strength to carry the entire load of the car and also to support and align the center sills against buckling. This system of high-truss side frame herein outlined is applicable to any type of car body construction.

The author discusses various other points of car design, such as brake equipment, comfort of passengers, lighting, etc., and describes in some detail the brake equipment supplied for the Rapid Transit subway cars. He illustrates his paper by numerous photographs referring mainly to the New York, Westchester & Boston Railway.

RAILWAY SIGNAL ASSOCIATION

Journal, vol. 19, no. 1, March 1914, Bethlehem, Pa.

Tests of Creosote Used in Treating Cross Ties
Tests of Cross Ties Treated with Creosote (Abstracted)
Specifications for Wood Pole Line Brackets
Specifications for Pole Line Washers
Specifications for Edison Storage Battery

TESTS OF CROSS TIES TREATED WITH CREOSOTE (2½ pp. *c*). Creosote from Carbondale, Ill., was used. The main problem of the test appears to have been to determine the conductance of the ties when dry, wet, or containing a large amount of common salt. It was found that dry creosoted ties in themselves do not possess very high conductivity, which is not increased to any great extent by the addition of a slight percentage of moisture, but the addition of a salt solution brought forth such a great reduction in the resistance as to brand the substance as a great detriment to successful track circuit maintenance. In this case, 2 lb. of salt per tie were applied, which at first sight appears to be an excessively large amount, but the accumulation of brine from refrigerator cars year after year may mean that the residue remaining in the tie may eventually approach the amount used in this test. The cross-grain measurement tends to prove that the resistance is less with the grain than along the year rings or radial lines.

ROYAL SOCIETY OF ARTS

Journal, vol. 62, no. 3196, February 20, 1914, London

THE PRESERVATION OF WOOD, A. J. Wallis-Tayler (29 pp., 12 pp. *dg*). The author enumerates various methods for the preservation of wood and discusses them in detail, referring chiefly to American practice and investigations made in this country by Mr. Bailey of the Harvard School of Forestry. He gives a list of the various processes of wood preservation used, with a brief statement of the nature of each of them as well as a list of preservative solutions.

The article presents an excellent compilation of material on wood preservation in a brief and clear form, but does not claim to include any facts not otherwise published. In the discussion which followed, Mr. J. B. Murray stated that he knew of a process which did not affect the appearance of the wood otherwise than slightly darkening it and yet gave very effective protection against fire. If treated and untreated pieces of wood were applied to a Bunsen burner, the untreated wood would burst into flame, but the treated piece would not; it would char, but not flame.

Mr. Wallis-Tayler stated that he believed that one proprietary substance was utilized by the British Post-Office authorities for rendering timber fire-proof; it is also odorless and a good antiseptic. His experience as an engineer to Sir Charles Tennant, on sugar estates in the West Indies, proved that pieces of wood thoroughly impregnated with a saccharine solution were practically indestructible so far as rot was concerned; he had, however, no experience in the use of saccharine matter for large timbers, although he knows that negroes and coolies dip the handles of their tools with an object to strengthening them.

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 19, no. 1, January 1914, Chicago

Factors Determining a Reasonable Charge for Public Utility Service, M. E. Cooley
Testing of Horizontal Low-Head Water Turbines at Elkhart, Indiana, Lucius B. Andrus (Abstracted)

The Grand Stand for the University of Chicago, Charles Hodgdon

TESTING HORIZONTAL LOWHEAD WATER TURBINES AT ELKHART, INDIANA, Lucius B. Andrus (54 pp., 18 figs. *de*). The author describes briefly the Elkhart hydro-electric plant in Elkhart County, Indiana, consisting at present of two complete water turbine units for driving two 1000 kva. 3 phase 4 wire 400 volt 60 cycle generator units and one 125 volt, 1/100 kw. direct current exciter generator with suitable oil pressure horizontal water wheel governors for controlling the speed of each of the water turbine units. The tests of the present machinery were made at Holyoke Water Power Company's plant at Holyoke, Mass. In Holyoke there are at present 158 water wheels in use, some of them running 10 hours per day and others from Sunday midnight to Saturday midnight, or 144 hours per week. Observations are taken giving the opening of the speed gate of each wheel and the head acting upon it, once a day and once during each night. These data are carefully preserved and from them are computed the amount discharged by each wheel and by each establishment during the quarter year, and what is known as "surplus power" thus shown to have been used is paid for at the end of the quarter. This system results in economy in the use of water and prevents the possibility of the use of same by some parties to a greater degree than the lawful quantity at any or all times and of a disregard of the rights of any other parties. This system, however, requires keeping track of the efficiency of the tur-

TABLE 3 COMPARATIVE DATA OF VARIOUS MAKES OF ELECTRIC TRAIN LIGHTING EQUIPMENT

Makers	Single or Double-battery System	Method of Transposing Batteries in Double System	Type-Constant Current or Constant Voltage	Pole-changing Device	Method of Regulation	Method of Adjusting Output	Type of Automatic Switchgear	Voltage Compensation in Lamp Circuit when Charging	Alteration of Compensation when Lamps are Switched	Alteration to Output when Main Lamp Switch is Operated	Overcharge Preventer (Type)
J. Stone & Co.	Double	On reversal of rotation (mechanical)	Constant current	Switch arm governor-operated	Slipping belt	Belt tension	Mechanical	Second battery	None	None	None
Leeds Forge Co.	Single	.....	Constant current	Brush rocker	Cam slides armature	Spring collar adjusting nut	Electrical	Lamps across fewer cells	Self-compensating	None	Breaks field current
Mather & Platt	Double	By hand switch	Constant current	None required	Armature reaction	Field resistance	Electrical	Second battery	None	By field resistance	Adds field resistance
Vicars, Ltd.	Single	.....	Constant current	Brush rocker	Automatic rheostat	Diverter	Electrical	Automatic rheostat	Automatic rheostat	Diverter has some effect	Switches extra shunt coil to main a to rheostat
Tudor Co...	Single [1]	.....	Constant current	Brush rocker	Counter compounding	Diverter	Electrical	Hot iron-wire resistances	Separate wire resistance	By field resistance	Adds extra field resistance
Silvertown.	Double	Mechanical	Constant current	Governor-operated	Counter compounding	Diverter	Mechanical	Second battery	None	None	None
Brown-Boveri	Single	.....	Rising voltage if lamps not on	Brush rocker	Voltage regulator	Adjustment of regulator	Electrical	Fixed resistance	Regulator alters dynamo volts	Regulator alters dynamo volts	[2] Adds resistance in regulator circuit
Dalziel.....	Single	.....	Constant [3] voltage	None required	Differential exciter	Rheostat	Electrical and mechanical	Resistances	Each lamp or group of lamps on separate resistance	Battery charging independent	None required
Grob.....	Double [4]	Mechanical	Constant voltage	Mechanical	Series excitation armature bucking against regulating battery	.....	Mechanical	Lamps on dynamo; battery on booster	None required	Battery charging independent	None required
Buttner....	Single	.....	Constant current	None required	Armature reaction	Field resistance	Electrical	Hot wire resistance	Separate hot wire resistance	By field resistance	Adds extra field resistance
Newbold...	Single	.....	Constant current	Mechanical	Automatic rheostat	.....	Electrical	Resistances	Separate resistance	By extra coil on regulator	.....
Gould.....	Single	.....	Compound	Mechanical	Carbon powder regulator. Series and shunt	.....	Electrical	Separate regulator	Separate regulator	.....	Shunt coil of regulator

[1] Requires 25 per cent more cells on account of hot wire resistance losses. [2] The charge to the battery is increased when more lamps are switched on [3] Pure constant-voltage system. [4] Has one battery as regulator.

bine wheels, and, for the purpose of making the necessary experiments on the wheels of their tenants before they are set in the mills, the Holyoke Water Power Company has built a permanent testing flume, where wheels are usually tested at five or six different openings of the speed-gate with a final result that, for all practical purposes, the water wheel has been converted into a water meter and its discharge may be known under any of the conditions under which it is found in the mill, while its efficiency or value as a water meter is also known.

The Holyoke Water Power Company being fitted to make these tests at any time, winter or summer, and with many tests to make, it can afford to charge only a moderate amount for the test. Thus, while formerly the cost of a wheel test might readily amount to $2500, it can now be done in the special plant at a cost of from $100 to $150. There are, however, three factors of the Holyoke test which are practically fixed and do not apply to the conditions under which the water turbine will necessarily operate in a power installation:

a The head at Holyoke under which the wheels are tested may be considerably different from that at which the wheels will operate when permanently installed.

b The wheels are tested in a vertical position at Holyoke and may be erected in a horizontal position when permanently installed.

c The length of the draft tube and its form are fixed within limits in the Holyoke testing plant.

The author describes in detail how the present test was made, and in particular how the generator efficiency has been determined—the test weir arrangements, weir head water gagings, and the various weir discharge corrections. He also describes in some detail the method of conducting the test and taking the readings. In an appendix to the paper is given a complete log of the test for a 50 in. horizontal low-head water turbine showing that the actual efficiencies come within approximately 1.5 per cent of the guaranteed efficiencies—an unusually good showing for turbines of this size.

As regards the applicability of water turbines for commercial work, the author points out that owing to the high cost of overflow land, as it has to be acquired by the water power companies, and with the usual American low-head, it will cost about $250 per kw. by the time the development is completed. Now on this sum, one must allow at least 6 per cent interest, 3 per cent for depreciation and contingencies and 1 per cent for taxes, or a total of 10 per cent, equal to $25.00 per year per kw. fixed charges on a water power plant, with an attendance cost of about $4.00 per kw. per year, or total about $29.00 per year. Now a good modern steam plant will have approximately $15.00 manufacturing costs and $15.00 fixed charges per year, or a total of $30.00 per kw. per year. From a monetary standpoint there is therefore no appreciable advantage in a water power plant as compared with a steam plant, but sometimes as a matter of business policy it is preferable to build the water power plant first lest somebody should come in later on, build it and force you to buy him out in the end. The governor used was the one manufactured by the Lombard Co. It is not a standard governor, but was made for these conditions—a governor head operating the governor ball and admitting the oil to the piston is standard, but the piston or the other parts working on the shaft, moving back and forth have not been standardized. Referring to the cross section of the Holyoke test flume, the makers' guarantees were in this case based on the efficiencies obtained from the Holyoke testing flume. In the Holyoke test the wheel is used as a water meter instead of a water wheel, but when the Company finds out how much power a man has and how much water is going through the mill, they have the figures for the efficiency, and the man who can get the most power out of a certain amount of water is the man who sells the most wheels. As a result, different manufacturers would change wheels to satisfy their customers and send them down to the Holyoke Company to be tested, but this Holyoke test would not necessarily prove what the wheel could do when it was in position. For example, a test of a wheel was made at Holyoke where, by shifting it up so that four feet were added to the draft tube length, an increase in efficiency was secured of ½ per cent for each additional foot of draft tube. With right draft tube conditions, one can therefore obtain a higher efficiency on the wheels than can be obtained at Holyoke due to the draft tube conditions there.

THE SOCIETY OF ENGINEERS

Journal and Transactions, vol. 5, no. 1, January 1914, London

Electric Lighting of Steam Driven Trains, E. Kilburn Scott (22 pp., 14 figs. *ed*). The paper discusses the electric lighting of steam driven trains. It gives a brief historical sketch and the standard requirements for satisfactory train lighting system as well as a description of the apparatus used. As regards the switch regulator, which is a most important part of any system, the conditions with which it must comply are stated in the words of Rudyard B. Smith, from his paper before the Institution of Civil Engineers. The author describes in some detail the systems of Mather & Platt, Ferguson and Newton.

He also gives a brief discussion on the management of storage batteries and lamps, and expresses the opinion that Tubolite, the system of electric lighting used by shipbuilders, is suitable for illuminating railway coaches. In this system, which has been adopted on some cars of the Great Northern Railway Company in England, the long Tubolite lamps are held by means of porcelain holders in the position of maximum efficiency relative to a highly polished aluminum reflector. The light is directed upward to the white roof of the carriage and, by reflection, produces a clear well diffused light throughout the whole car. There is no direct glare and the amount of useful light for a given consumption of energy is greater than with the ordinary incandescent bulbs.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

PERSONAL NOTES

A membership pin was recently found in Pittsburgh and is now in the rooms of the Society, where it may be secured by its owner.

At the meeting of the Council on March 13, the Secretary was instructed to convey to George A. Orrok the satisfaction of the Council over the reports of his improving health, and their hope that he may soon be able to take up his former active participation in the Society's affairs.

Prof. F. R. Hutton, Honorary Secretary, delivered an address before the officers of the U. S. Army detailed to the Aviation School of the U. S. Signal Corps, on the morning of March 7. His topic was the Line of Responsibility of the Designer and Operator of the Internal-Combustion Motor, and the meeting was held in the hangars of the post on North Island, San Diego Harbor, Cal.

George K. Miltenberger, formerly general manager of the Fulton Electric Light and Power Company, Fulton, Ky., has become associated with the Perry County Public Utilities Company, of Perryville, Mo.

W. E. Winship has accepted the position of general manager of the Titan Storage Battery Company, Newark, N. J. He was until recently connected with the Adamant Battery Company, Boston, Mass., in the capacity of vice-president.

W. M. Bosworth has been appointed mechanical engineer of the Louisville and Nashville Railroad Company, with headquarters at South Louisville, Ky. Mr. Bosworth was, until recently, associated with the Kansas City Southern Railway Company, Pittsburg, Kansas, in the same capacity.

Russell W. Stovel, formerly connected with Westinghouse, Church, Kerr & Company, New York, as managing engineer, has become identified with Gibbs & Hill, Consulting Engineers, New York.

George J. Gauthier has severed his connection with the Trinidad Electric Transmission Railway and Gas Company, of Trinidad, Colo., and has become associated with Messrs. Allan and Jones under the firm name of Gauthier, Allan & Jones, with headquarters in Minneapolis, Minn.

H. Howell Wilson has become associated with the United Gas and Electric Engineering Corporation as engineer of power stations of the American Gas and Electric Engineering Corporation, with headquarters in New York. Mr. Wilson was, until recently, superintendent of power plants of the Baltimore & Ohio Railroad Company, Baltimore, Md.

Peter Eyermann, formerly engineer of construction of the Witkowitz Steel Works, Witkowitz, Austria, has been appointed general superintendent of the new Austrian Steel Industry Company, Brux, Bohemia, Austria.

Willard H. Cobb has become identified with the manufacturing department of the New York Belting and Packing Company, New York. He was formerly assistant engineer of Westinghouse, Church, Kerr & Company, New York.

J. W. Sheperdson, assistant chief engineer of the Cambria Steel Company, Johnstown, Pa., has resigned to accept the position of assistant general superintendent of the Central Iron & Steel Company, Harrisburg, Pa.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a meeting of the Armour Institute of Technology Student Branch on March 4, the following officers were elected for the coming year: F. L. Brewer, Jr., president; A. A. Anderson, vice-president; J. A. Agee, secretary; W. L. Juttemeyer, treasurer. Oscar Goetz (1914) gave a talk on Kerosene Carburation, and Lyman Close (1915) on Vehicle Springs.

COLUMBIA UNIVERSITY

A meeting of the Mechanical Engineering Society of Columbia University on February 19 was addressed by two of the student members, R. P. Piperoux (1914) and H. F. Allen (1915). Mr. Allen gave an account of his summer shop experiences at the Cooke Works of the American Locomotive Company, describing the layout of the plant, the work produced, and the methods employed; while Mr. Piperoux gave a talk on the Power Plant of the French Liner, La France, in which he described the engine room and gave many interesting figures concerning the capacities and consumption of its various units.

CORNELL UNIVERSITY

William Kent addressed the Sibley College Student Branch on February 17 on the General Manager. He mentioned the fact that few men have the capacity to advance to high executive positions, and said that the qualifications necessary are health, education, special knowledge, tact, energy, industry, personality, initiative, aggressiveness, and a degree of laziness.

KANSAS STATE AGRICULTURAL COLLEGE

The organization meeting of the Kansas State Agricultural College Student Branch was held on February 20, and the following officers were elected: A. A. Potter, Honorary Chairman; Victor Whiteside, president; J. D. Parsons, vice-president; J. I. Michaels, secretary; C. W. Wyland, treasurer. Prof. J. D. Hoffman gave an address on Fundamentals in Heating and Ventilating, in which he made clear the distinction between inanimate engineering, i.e., piling up dollars, and animate engineering, i.e., accumulating health. To show the poor ventilation of the average public meeting place some very interesting figures were given. The paper was discussed by Shelby Fall, Prof. L. E. Conrad, C. W. Lane, Prof. A. A. Potter, G. B. McNair, and P. L. Meyrick.

LELAND STANFORD JUNIOR UNIVERSITY

At a meeting of the Leland Stanford University Mechanical Engineering Society on February 10, a paper on the Sugar Industry in the Hawaiian Islands was read by J. A. Gibb, one of the members. This covered the author's experiences in the islands for the last two years. A general discussion followed.

On February 17, a joint meeting of the mechanical, electrical, geological, mining, and civil engineering societies was held, at which M. M. O'Shaughnessy, city engineer of San Francisco, spoke on the Water System of San Diego, covering the subject from the time of the Mission Fathers to the present.

A paper on Irrigation Pumping Machinery, by W. H. Warren, and another on the Automatic Telephone, by C. F. Williams, were read at the meeting of February 24, and were discussed by those present.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On March 4, C. B. Sawyer of the Dodge Manufacturing Company gave a brief and interesting talk on various kinds of driving, and showed a comparison of these various kinds with rope driving, before the Student Branch of the Massachusetts Institute of Technology.

On March 11, B. K. Hough, the New England representative of the Richardson Scale Company, gave a talk on Automatic Weighing and the precision which might be expected from the use of this system as applied to grain and coal, and also water. He explained at length the advantages of the uses of the equal balance and the drip systems.

MISSOURI UNIVERSITY

At a meeting of the Missouri University Student Branch on February 16, the following officers were elected: F. A. Huleman, chairman; F. H. Frauens, corresponding secretary; L. L. Leach, secretary and treasurer. Professor Newton gave a talk on pig casting machines, discussing the various makes and their advantages and disadvantages.

On March 2, L. L. Leach gave a talk on the operation of mines in southwestern Missouri and the design and construction of the machinery used there.

OHIO STATE UNIVERSITY

The following officers were elected at a meeting of the student branch of Ohio State University on February 26: C. J. Lauer, chairman; C. R. Codner, vice-chairman; L. W. Ganschow, secretary; H. D. Winbigler, treasurer.

On March 5 a banquet was held at which Profs. W. T. Magruder, E. E. Sanborn, Horace Judd and F. W. Marquis, and A. I. Brown, and Robert Neilan responded to toasts, coöperation being the keynote of the evening's discussion.

PENNSYLVANIA STATE COLLEGE

A meeting of the Pennsylvania State Student Section was held on February 19, at which reports of the senior inspection trips to New York, Philadelphia and Harrisburg were presented. Professor Mease spoke of the benefits derived, and a detailed description of the various plants was given by H. L. Swift.

On March 13 a joint meeting of the branch and of the Motive Power Club was addressed by C. E. Barba and H. A. Hey. Mr. Barba emphasized the necessity of the coöperation of the drafting and manufacturing departments of an industry; and Mr. Hey of the new field opened to engineers by the recent demand for greater safety and increased efficiency. He stated further that the Society stood ready to help the student members whenever possible and urged all to take advantage of its help. A reception was held at the close of the meeting.

POLYTECHNIC INSTITUTE OF BROOKLYN

On March 7 the Student Branch of the Polytechnic Institute of Brooklyn listened to an interesting paper on Safety Valve Capacity by William R. Van Nortwick of Manning, Maxwell & Moore, Inc., in which he pointed out the need of having excellent safety valves, since the modern tendency in power plants was to run the boilers above rated capacity. He illustrated by lantern slides that many boiler explosions were due to poorly designed safety valves.

STEVENS INSTITUTE OF TECHNOLOGY

The Stevens Engineering Society held a meeting on January 13, at which Frederick W. Taylor gave a talk on the Principles of Scientific Management.

SYRACUSE UNIVERSITY

On February 24, J. E. Rood (1914) gave a talk on the History and Development of the Steam Engine, before the Student Branch of Syracuse University. He briefly described the early so-called engines and contrasted them with the types of today; comparing them, in conclusion, in respect to their ability to use the B.t.u.'s generated from 1 lb. of coal. Prof. W. E. Ninde followed with a talk on the Value of the Early History of the Steam Engine to the Engineering Student.

UNIVERSITY OF CINCINNATI

J. I. Lyle gave an address before the Student Branch of the University of Cincinnati on February 12 on Air Conditioning Machinery, in which he discussed the subjects of dust prevention and humidity, illustrating his remarks by lantern slides.

On February 20 the branch made an inspection trip to Dayton, Ohio, where a number of plants were visited, including the Home Telephone Exchange, the home of the Delco motor starter, the National Cash Register Company, and the Dayton Power and Light plant.

On March 10, George K. Elliott of the Lunkenheimer Company gave a talk on Steam Value as a Metallurgical Problem. He spoke of the present day requirements essential for a good value and how different metals were alloyed to obtain these properties. The lecture was illustrated with some fifty slides, the microscopic views showing metal structure being exceptionally good.

UNIVERSITY OF ILLINOIS

The following officers were elected at a meeting of the University of Illinois Student Branch on February 27: C. R. Velzy, president; J. A. Wilson, vice-president; E. F. Gehrig, secretary; J. L. Alden, treasurer.

UNIVERSITY OF IOWA

On February 25 at a meeting of the Student Branch of the University of Iowa, F. A. Wahlgreen gave a talk on Some Features of the Keokuk Dam, describing the transmission lines and the dam itself.

UNIVERSITY OF KANSAS

Prof. F. W. Blackmar, Dean of the Graduate School of the University of Kansas, gave a talk before the Student Branch on March 5 on Some Factors of the High Cost of Living.

UNIVERSITY OF MAINE

On February 25 the Student Branch of the University of Maine attended the automobile show, holding a meeting in the auditorium. Full lines of nearly all the standard machines were shown, and the demonstrators explained the new improvements to the members.

UNIVERSITY OF MINNESOTA

At a recent meeting of the Student Branch of the University of Minnesota the following officers were elected: J. A. Colvin, chairman; J. L. Hartney, vice-chairman and corresponding secretary; R. R. Boyles, secretary; A. W. Holmberg, treasurer. A review of Mr. Polakov's paper, presented at the Annual Meeting of the Society, was given by James A. Colvin.

UNIVERSITY OF WISCONSIN

At a meeting of the Student Branch of the University of Wisconsin on February 13, Prof. J. G. D. Mack gave an instructive talk on the life of John Ericsson.

On March 5, Prof. A. G. Christie gave a talk on the Measurement of the Flow of Air, which was a brief of the paper by W. C. Rowse, presented at the Annual Meeting of the Society.

WASHINGTON UNIVERSITY

A. W. Lomis of the Westinghouse Electric Company gave an illustrated talk on Steam Turbo-Generators before the Washington University Student Branch on February 14, in which he compared the relative merits of the reaction type with the impulse.

YALE UNIVERSITY

The Yale Student Branch held a meeting on February 17 at which Dr. D. S. Jacobus gave an illustrated talk on the Construction and Operation of Steam Boilers. He followed the development of the Babcock & Wilcox boiler from the early types up to the present stage, and also discussed oil-burning boilers, comparing their efficiencies with those of the coal-burning boilers. A. C. Staley, Prof. L. P. Breckenridge and others discussed the paper.

On January 21, H. L. Gantt made an address on Training Workmen in which he emphasized the fact that the greatest increase in the efficiency of mill workers was obtained by giving them individual instruction on how to perform their work. He illustrated the effect of the bonus system by charts.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The published list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

301 Chief engineer, by concern employing 1000 men manufacturing threshing machinery, steam and gas tractors. Applicant must be good executive, progressive, with ability to handle men and must be thoroughly competent to take charge of design and drafting work. Give address with information as to past experience, age and salary expected.

302 Assistant manager, by foundry making a specialty of medium and light weight steel castings of high grade. Must be capable of taking complete charge of production in the absence of general manager.

304 Expert steel man, engineer, good executive, familiar with manufacture of steel. Must have wide acquaintance and ability to secure confidence of steel men. Headquarters at Pittsburgh, but considerable traveling in this country and abroad. Name confidential; apply by letter.

306 Draftsman, experience in designing small motors or generators for automobiles, for factory manufacturing small interchangeable parts for electrical apparatus. Location, Massachusetts. Only those having three or four years' experience need apply. Salary $18 to $22.

307 Production manager, old establishment in Connecticut, requires a man of great force in field of manufacturing management. Applicant must have dominate influence in deciding what articles to drop from the present line, what to continue manufacturing, the equipment necessary to manufacture them at profit, and what new lines to set up. Class of goods is light brass ware and in conjunction with this firm is a good sized gray iron foundry.

309 Technical graduate; at least three years' experience, with capital to take financial interest and actively engage in a well developed consulting business in New York City. Confidential; apply through the Society.

320 Manager for oil and gas burning furnace department. Must be 30 or 35 years of age, with some selling experience or adaptability in this direction. Preference given to man with technical training as a mechanical or chemical engineer.

337 Draftsman; experienced in and capable of developing the design of water tube boilers, including setting plans. Must be neat, accurate workman, and have thorough technical and practical experience along this line. Confidential; apply through the Society.

338 Technical expert in purchasing department of large works near New York, making high-grade light metal products, to assist in selecting, buying and inspecting the many varied materials used; should be good metallurgist, fair chemist and familiar with fuels. Name confidential; apply by letter. Applicants should give age, education, experience, reference and approximate salary expected.

339 Master mechanic or plant engineer, up in power plant engineering, general plant engineering, and able to reduce cost of repairs and manufacture of equipment. Also one who has had all-round experience in engineering problems pertaining to plant operation.

340 Experienced sales manager who can invest about $5000 in a company manufacturing fireproof heat insulating and building material. Salary to be agreed upon. Little traveling. Location, New Jersey.

341 Technical graduate to take financial interest and if desired engage actively in water tube boiler specialties business, with a graduate of 20 years' business experience, who controls the United States patents. An interview in New York is requested. Name confidential; apply through the Society.

MEN AVAILABLE

140 Member; trained as a mechanical engineer and machinist, with experience as superintendent; for eight years conducted office as designing and contracting engineer. Desires position as representative of high-grade concern, preferably in field of equipment for the handling of materials in Ohio, and adjacent states, if necessary.

141 Associate-Member; 27 years of age, technical graduate. Four years' experience with one of the largest manufacturers of steam turbines in the country. Experienced in design, construction testing, and field erection of steam turbines, condensers, and power plant equipment; thoroughly familiar with power plant work and would be able to handle position as superintendent of power plant. Desires position with reliable firm of consulting engineers. Is willing to take part interest in business with right party.

142 Junior, M.E.; familiar with modern shop and office practice; good organizer; experienced in boiler manufacturing and general plate work in engineering. Desires position as manager or assistant manager of manufacturing concern or a department.

143 Technical graduate, age 37, with continuous experience since graduation in engineering work, chiefly in design of power plant, mining and mill machinery. More than ten years in charge of work as chief draftsman and chief engineer.

144 Member; production engineer and manager; experienced designer, organizer and producer; familiar with best methods of management, quality and speed production for

machinery, metal goods and textiles. Operated under Taylor system and others. Present work completed about June 1, and applicant desires permanent connections with growing or large concern desiring to maintain with its own organization a permanent policy of efficiency and improvement.

145 Member; wide experience in machinery, metals, processes and their requirements; has filled efficiently every position from machinist to production engineer and knows the cost of production and the value of quality. Accustomed to placing rigid contracts at rock bottom prices and can distinguish between low price and low cost. Desires a position as purchasing agent and engineer for large establishment.

146 Member; long experience, best references; competent to organize all departments of manufacturing plants along modern lines. Desires a position as works manager.

147 Mechanical engineer, Stevens graduate, with over ten years' practical experience in factory management, desires to locate as assistant to general manager or as works manager. Vicinity of New York preferred.

148 Associate, married; mature age, manager and director; experienced in developing and perfecting organization accounting, costs and analysis, selling departments and in the operation of complicated business. Long experience with maritime affairs both in this country and in Great Britain. Desires a position of executive responsibility.

149 Member, technical graduate, 31 years of age; extensive training and experience in central power station work, designing, purchasing, superintending construction and operating departments; consulting engineering work on large properties; power production investigations; cost reduction; experienced in mill and reinforced concrete construction work; at present employed, but desires a change for advancement. Desires a position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation.

150 Member; technical graduate, 39 years of age, with 15 years' experience in machine shops and general mill engineering, the latter in an executive capacity. Desires a position with a large concern in New England. Best references.

151 Member; technical graduate with advanced degree, specialty of efficiency engineering, 10 years' experience in heating and ventilating, power plant engineering and operation. Desires a position as engineer on operation and improvements, with company operating large power plants.

152 Associate-Member; Cornell graduate would be interested in a position as manager with a reliable concern, preferably a manufacturer of power plant apparatus. Personal interview requested.

153 General utility executive, technically educated as a mechanical engineer, who, under the titles of assistant vice-president and secretary, has served as a general utility man for well-known manufacturers of machinery; duties including sales, advertising, development of new ideas, pushing out work and general office management; seeks a responsible position where a wide engineering knowledge will be of value.

154 Associate-Member, Englishman, wishes to represent in London, England, an American concern. Wide experience in power plant machinery, its design, manufacture, operation and sales. Experience with several large concerns both in England and the United States; preferably a position with a small salary and commission. Intimate with the requirements of the British market in this line. Results guaranteed.

155 Junior; technical graduate, four years' experience in shop, drafting room, and office; at present employed as assistant to chief engineer with one of the large ball-bearing manufacturers. Desires a similar position with manufacturing concern along engineering lines. Salary $1500.

156 Junior member, technical graduate, fourteen years' practical experience, wishes position as superintendent or production manager.

157 Junior, age 29 years, graduate M.E.; eight years' experience in design and erection of steam power plants. Desires a position as constructing engineer or assistant to mechanical engineer with firm that can offer something of a permanent character. Salary $175-$200.

158 Junior industrial engineer, Junior member, college and technical graduate, five years' experience, desires position with concern contemplating installation of modern and systematic methods of manufacturing or starting the manufacture of a new product; can handle men and get results. At present and for the past three years employed as an industrial engineer by a large eastern manufacturing corporation; work nearing completion, therefore desires to establish new and permanent connection with manufacturers desiring executive of energy and ability.

159 Member; thirty years' experience in the largest engineering firms in England and America; nine years' experience as chief superintendent in steam turbine works, manufacturing all sizes from five to ten thousand horsepower. At present employed; desires permanent position as works manager or superintendent.

160 Junior, Stevens graduate, 30 years of age, varied experience in the office of a consulting engineer; complete charge of work and considerable responsibility. Has experience in reports, designs and appraisals of numerous industrial and power plants and municipal works. Best references.

161 Member; wide experience in designing, building and operating. At present in charge of large construction work nearing completion, also surface equipment of two mines and gravel plant on Pacific Coast. Has made special study of economical methods of handling materials. Accustomed to handling men, organizing crews, drawing up contracts, designing and purchasing. Is familiar with steel business. Desires connection with some large firm. Prefers to locate on the Pacific Coast.

162 Mechanical engineer, technical graduate, age 30, desires responsible position. Thorough knowledge of all types of pumps and pumping machinery, gasolene and oil engines, steam engines, and sugar house machinery. Drawing room, erection room and engineering department experience in large pump manufacturing company. Sugar plantation work in Mexico and sales engineer in Brazil. Natural ability in handling men and getting results. Best references.

163 Mechanical engineer, technical graduate, 25 years of age; several years' experience as factory inspector; familiar with all classes of manufacturing. Open for engineering work. Best references.

164 Member; wishes to get in touch with concern having ample machine shop facilities and organization for building and marketing new, fully protected, device for which there is a wide and profitable market.

165 Specialist in the practical manufacture of pumps, steam, gas, oil, gasolene and kerosene engines; sales work and power plant construction, and until recently vice-president of a million dollar corporation manufacturing all forms of pumps and prime movers. Desires connection with concern of some importance in capacity of engineer, or preferably, sales work.

166 Junior member, age 31, single, graduate in mechanical and electrical engineering departments of large technical

school, desires to make connection with firm where industry, capacity, and conscientiousness will be appreciated and rewarded. Applicant has ten years' experience in operating, designing and constructing substations, designing steel towers, selling small gas engines, city railway work. Can give best of references, and will start at a reasonable salary.

167 Member, 36 years of age; qualified to take charge of mechanical matters; experienced in designing, superintending construction and equipment of plants; some experience in purchasing and cost departments.

168 Junior member, age 27 years, graduate mechanical engineer, five years' experience in automobile manufacture and design, for the last two and one-half years in charge of experimental department in one of the leading automobile factories building a high priced car. At present employed.

169 Junior member; consulting mechanical engineer with office in Philadelphia wishes to arrange with a company in the vicinity able to use a portion of his time. Ten years' practical experience.

170 Member, technical graduate in mechanical and electrical engineering; six years' shop experience and four years as traveling salesman. Desires to represent a first class company in Philadelphia or vicinity as manufacturers' agent.

171 Managing sales engineer, open for contract to build up business with New York as headquarters. Has specialized in power plant equipment, contractors and conveying machinery. Practical shop and field experience; diplomatic and progressive.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am.Soc. M.E.

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The second edition has been rearranged and some new matter added. The fact that a new edition of 6000 copies is needed after four years is good evidence of the interest taken by factory managers in questions of administration.

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Heating and Ventilation. (cat. no. 215. B. F. Sturtevant Company.) *Hyde Park, 1914.* Gift of company.

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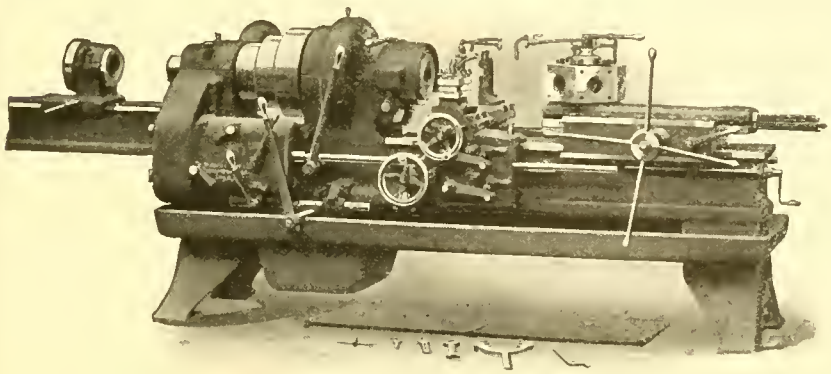

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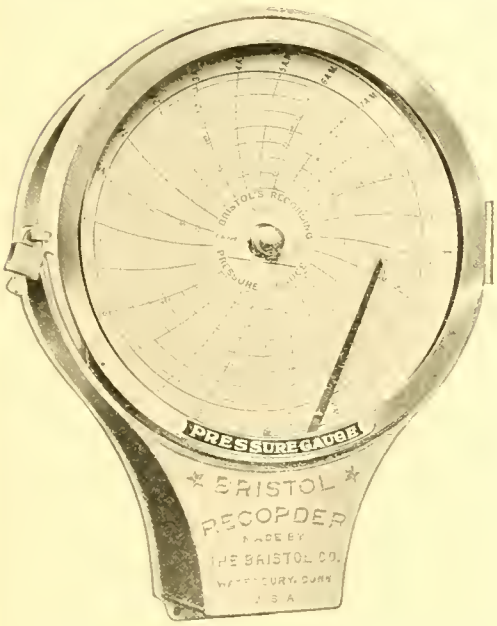

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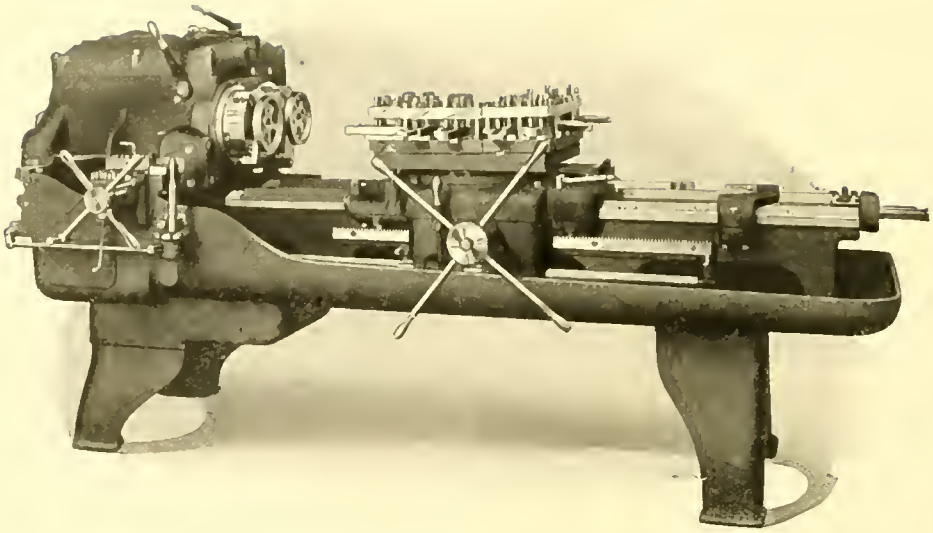

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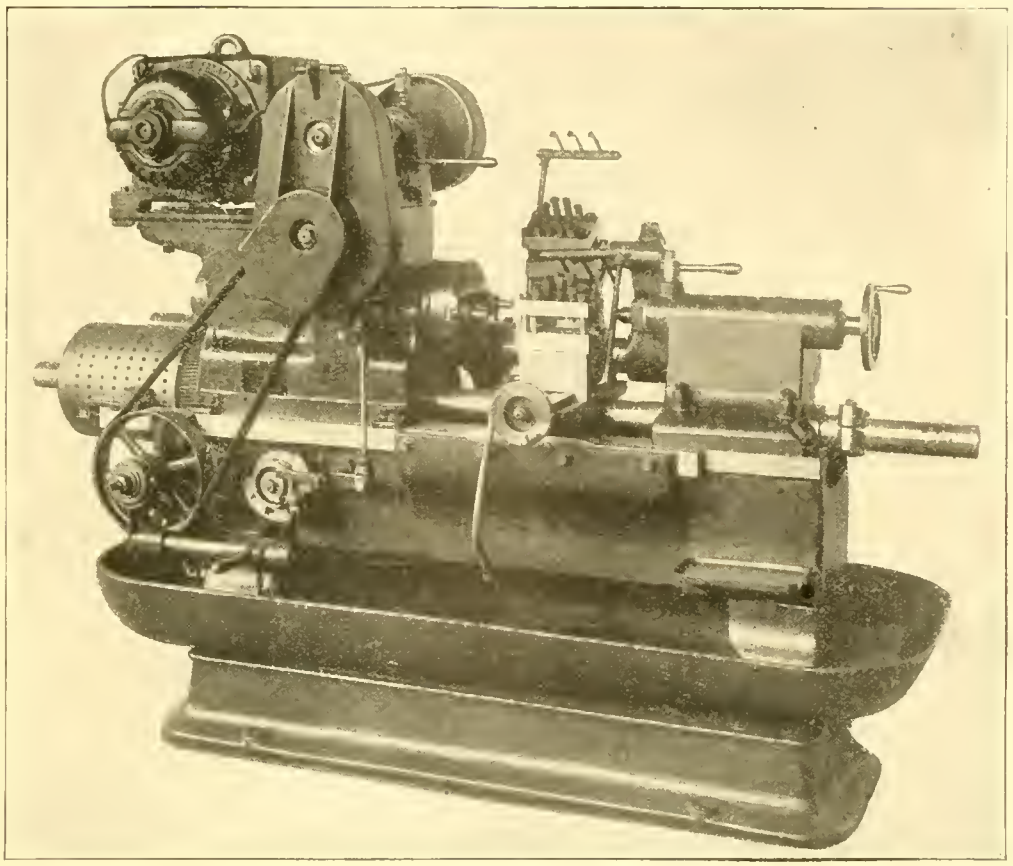

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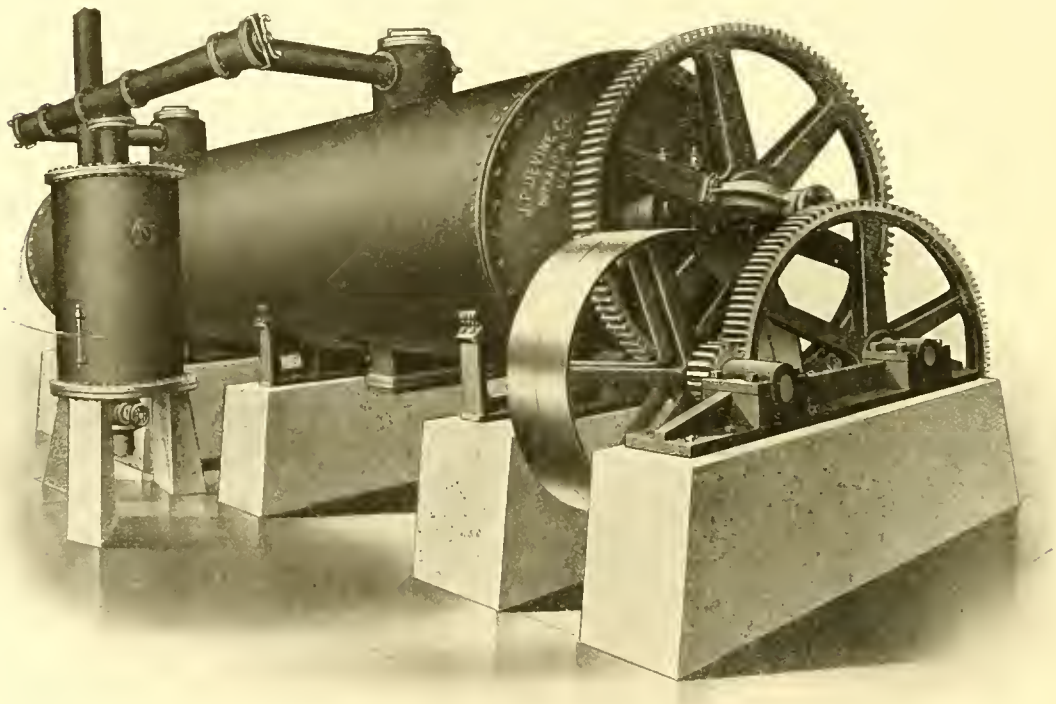

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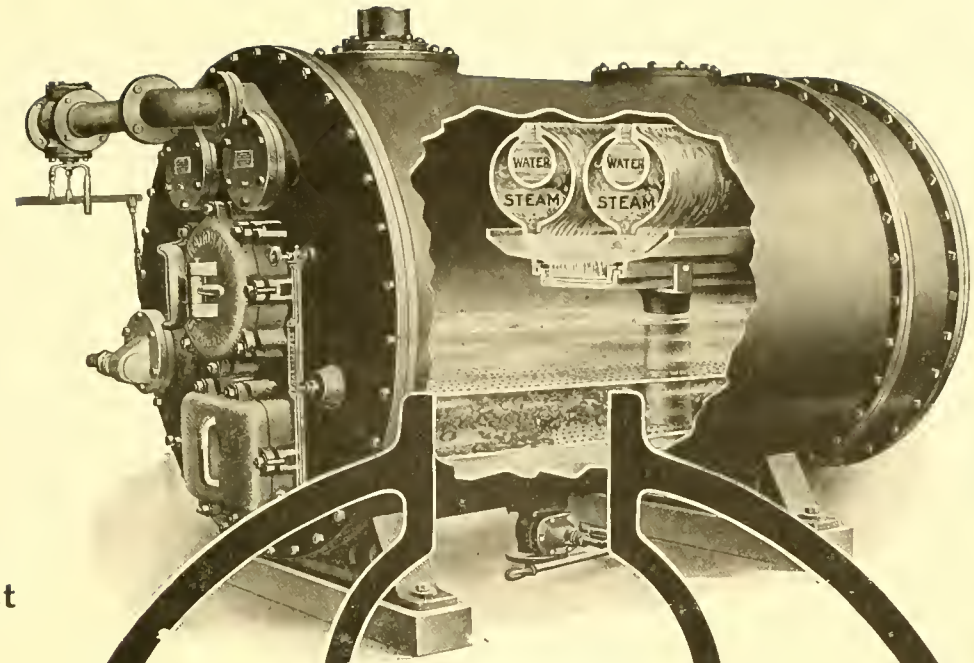

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the water is first heated by surface contact and then brought to maximum temperature by actual contact or mingling with the steam. This is the feature which distinguishes the National from all other open heaters. The contact pipes are double. From the inner, the water overflows the port at the top, and passes around the large pipe as a thin film. It is broken into fine spray at the bottom. The steam leaving the outer pipe at the bottom passes through the spray and finally all water and steam are in direct contact above the filter bed.

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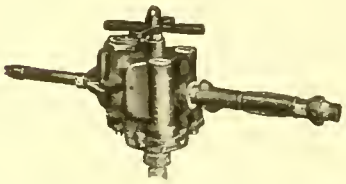

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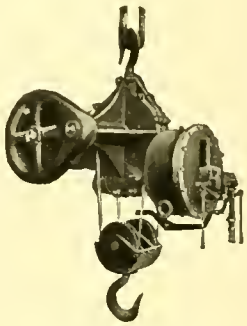

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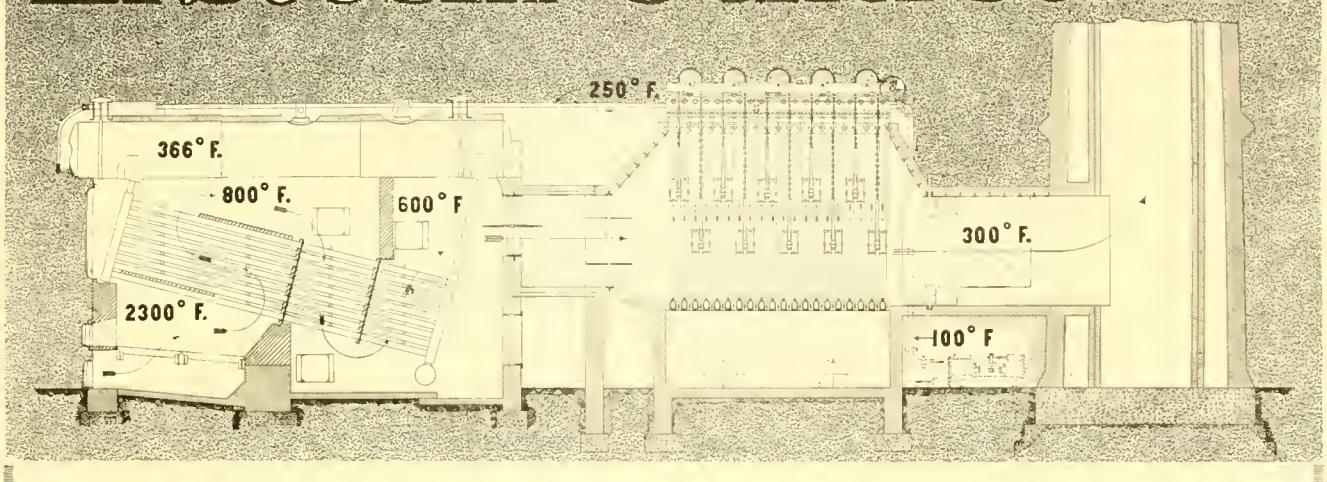

ALL the heat in the coal could be recovered by cooling the gases back to the temperature at which air enters the furnace, say 70 or 80 degrees F.

But the boiler alone cannot do this; in fact even with an infinite amount of surface, it cannot cool the gases below the temperature of the steam. For 150 lbs. pressure this is 366 deg. F.

As a matter of fact, **it does not pay to use the boiler surface to cool the gases below about 600 deg. F.** When the gases reach this temperature, the value of the heat absorbed by a square foot of boiler surface does not equal the cost of maintaining that square foot of boiler surface.

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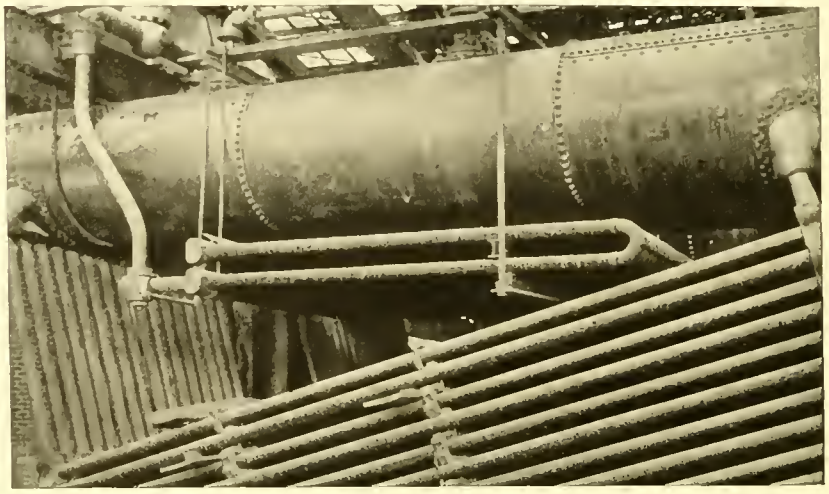

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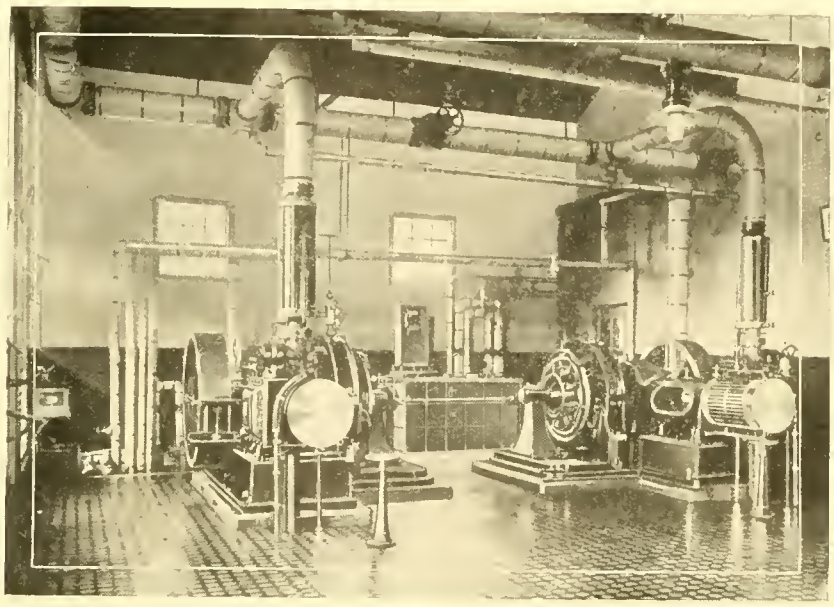

A Remarkable Test Was Made in this Plant

The 50,000 lb. per hour "Lea" Recording Meter shown in this photograph was used to test boiler feed at the Dartmouth College power plant. Two tests were made, covering both winter and summer load.

The winter test was run under exact working conditions of the plant at heavy load, a load which fluctuated badly, due to poor control on return water from the new gymnasium. The "Lea" Recording Meter, however, in a four hour test showed a difference of but 1.18% from the actual tank calibrated weights.

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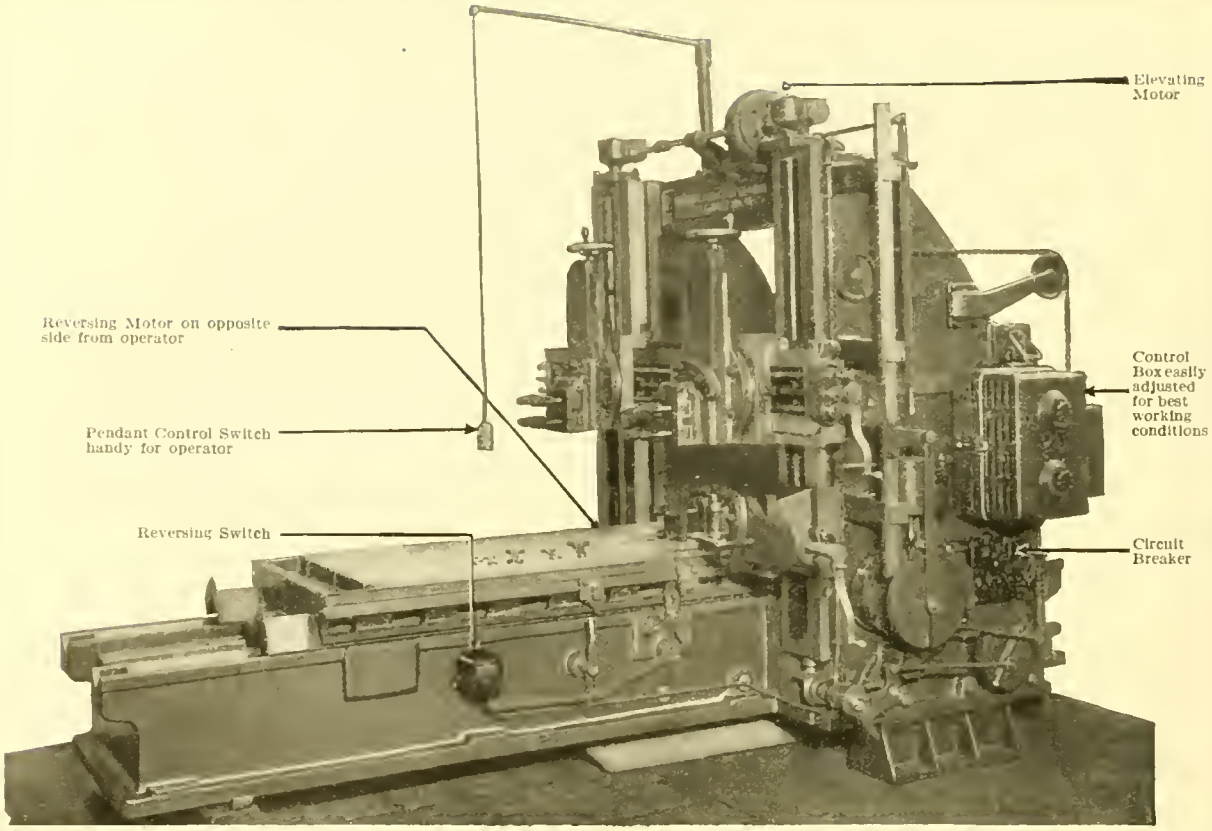

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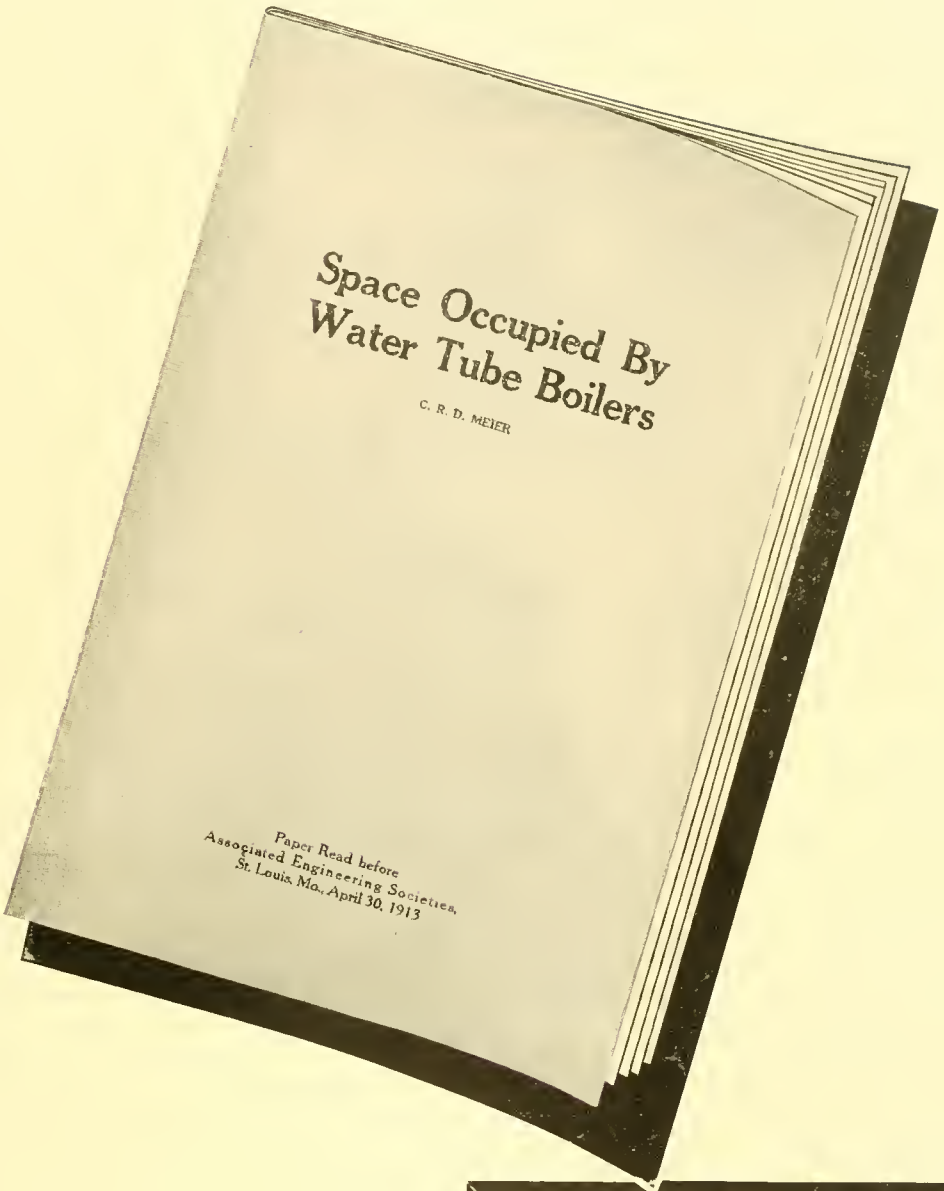

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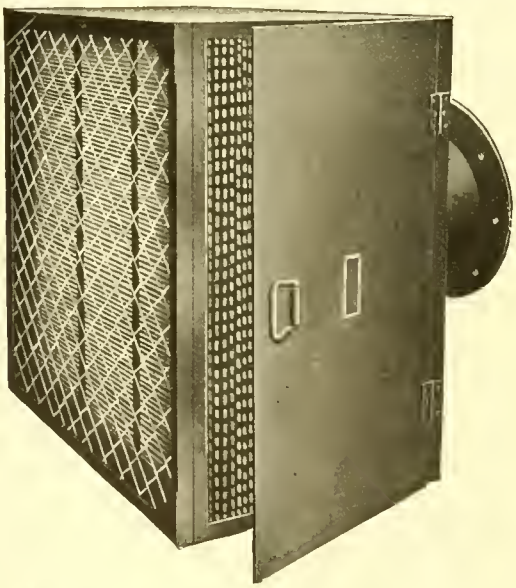

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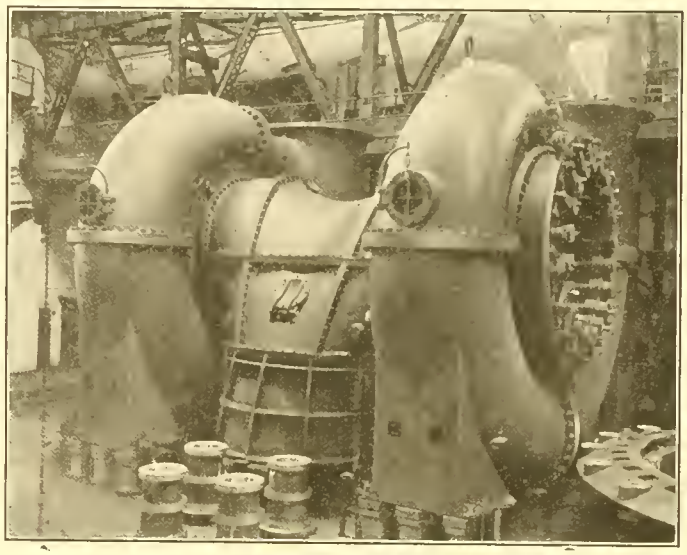

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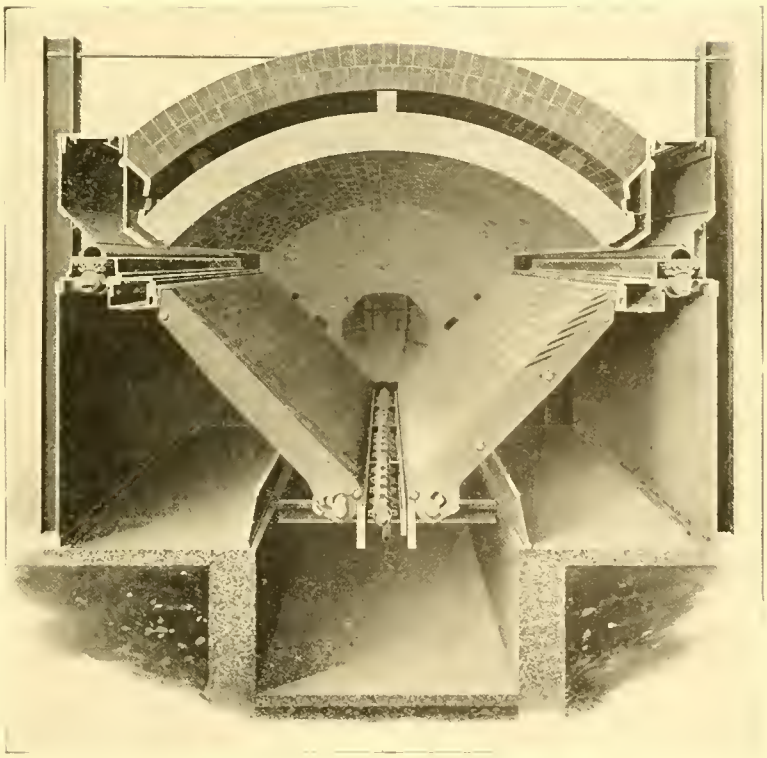

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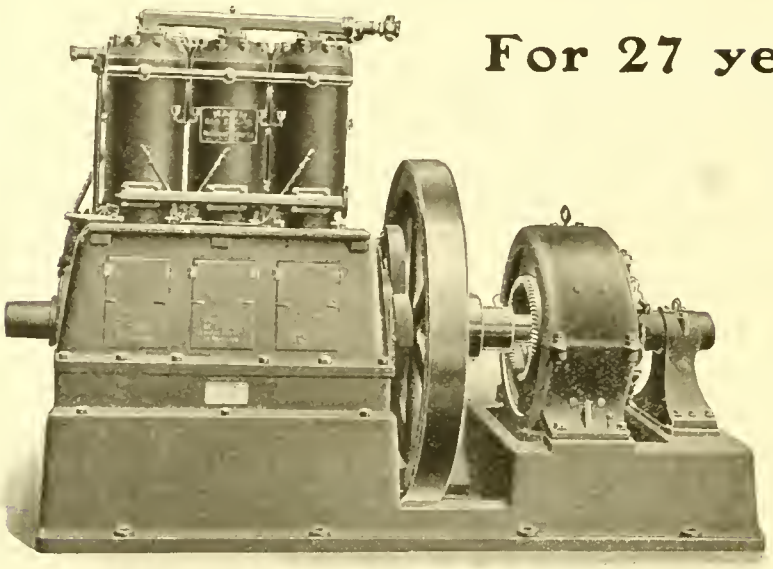

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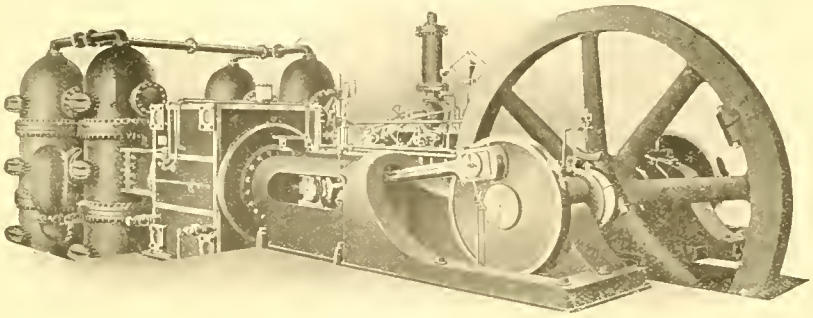
Horizontal Crank and Fly Wheel Pumping Engines

are particularly designed for hard service and long life and the valves are arranged in the annealed steel casting decks in such manner that the flow of water is not deflected in all directions, as is necessarily the case when the bee-hive or cage system is used.

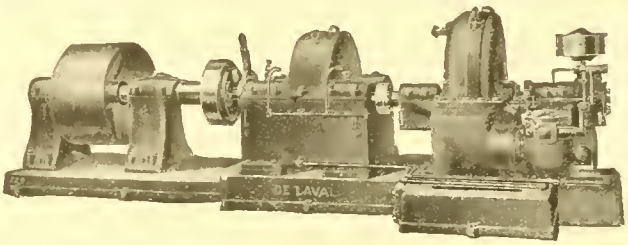


Hamilton Corliss Engines are the most economical steam operated prime movers known and are sold on their operating record.

Send for Bulletin "F"

THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO, U. S. A.



TURBINES FOR ROPE AND BELT DRIVE

THE ordinary turbine is not adapted to either belt or rope power transmission. With rope drive, for instance, the driving sheave should be 40 to 80 times the diameter of the rope, which calls for a sheave at least 30 inches in diameter.

The proper rope speed is 5000 to 6000 ft. per minute, which means only 763 r.p.m., altogether too slow for a steam turbine, particularly a small turbine, of any reasonable economy or number of stages.

In the case of belts the situation is nearly as bad. The diameter of the driving pulley should be not less than 100 times the thickness of the belt, although some authorities allow pulleys as small as 18 inches. With 4000 ft. per minute, the highest velocity recommended for belts, this gives a turbine speed of 850 r.p.m., again much too slow for the turbine

DeLaval Turbines, however, of the Single-stage, Velocity-stage or Pressure-stage types, are perfectly adapted to rope or belt drives through the use of the DeLaval Speed Reducing Gear. With this arrangement, the turbine can be operated at the most suitable speed for simplicity and efficiency.

The sheaves or pulleys can be of such dimensions as are most satisfactory for the life of the rope or belt.

The DeLaval Gear adapts the steam turbine to all services, particularly to driving standard speed direct current generators, centrifugal pumps, centrifugal fans and blowers, etc.

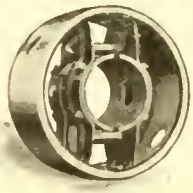
DeLaval Turbines likewise can be directly connected to all classes of machinery, rolling mills, line shafting, etc., in which services, great economies are often possible through the utilization of exhaust steam from other prime movers.

For further information, send for our catalogs D-58 and C-58 treating of our Pressure-stage and Velocity-stage Turbines respectively.

DE LAVAL
Steam Turbine Company

Trenton 116 New Jersey

A Pulley for Every Purpose



"Patented"
Design used in diameters of 3", 4" and 5".

"AMERICAN" STEEL SPLIT PULLEYS

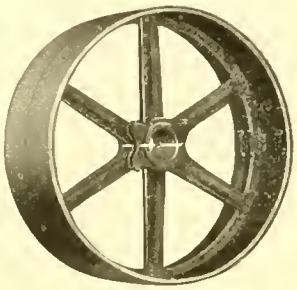
(*Made in diameters 3" to 60" inclusive*)

Their superior belt grip and strength, combined with lightness, have made them the most widely used metal pulley in this country.

Dealers Everywhere

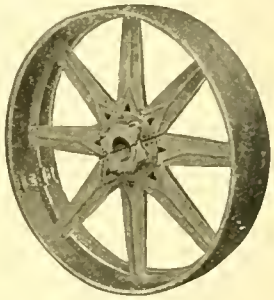
The American Pulley Company
Office and Works, Philadelphia, Pa.
New York: Cor. Grand & Greene Sts. Chicago: 124 Clinton St. Boston: 165 Pearl St.

"Patented"
Design used in diameters 44" to 60" inclusive with faces wider than 16".,



"Patented"
Design used in diameters 6" to 24" inclusive.

"Patented"
Design used in diameters 25" to 42" inclusive.



"Patented"
Design used in diameters 44" to 60" inclusive with faces narrower than 16".

Straight Running— Troughs Without Load— No Guide Idlers Necessary— No Spillage—

Goodrich LONGLIFE and MAXECON CONVEYOR BELTS

reduce tonnage costs—

Goodrich Conveyor Belts are extremely flexible, yet are of maximum tensile strength. Rubber covers resist the wear from abrasive, hard, heavy materials like ore, "sludge," rock, coal, cement, brick, sand, clay, etc., protecting the fabric body from moisture and other deteriorating and weakening influences.

Advise us regarding your installations. We make belts for every purpose.

The B. F. Goodrich Company

Makers of Goodrich Tires and Everything that's Best in Rubber

Factories: Akron, Ohio
Branches in All Principal Cities

There is nothing in Goodrich Advertising that isn't in Goodrich Goods

Goodrich Products

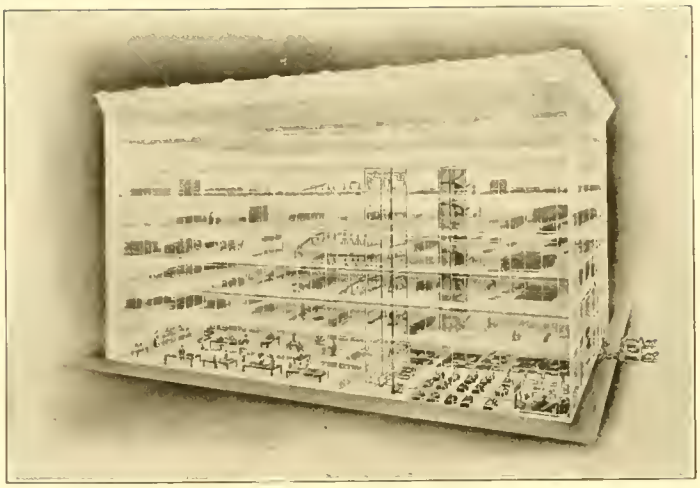
Conveyor Belts
Elevator Belts
Transmission Belts
Hose—All Kinds
Packing
Valves, etc.

Reducing the Pay-Roll—Improving the Product—Increasing the Capacity—

are the three most important accomplishments of a Conveyer System.

In these days of manufacturing retrenchment, architects and engineers are alive to the necessity of providing the best and simplest means for reducing time and labor in manufacturing processes. Development in gravity and power conveying devices have attracted wide and interested attention, and all promoters of industrial projects are giving the subject thorough investigation.

Be prepared to specify the best types of mechanical handling machinery by securing literature illustrating and describing the Mathews line of Standard Equipment—the oldest and best-known in America.



Complete System of Mathews Power and Gravity Conveyers in One of the Largest Shoe Factories in the World

GRAVITY ROLLER CONVEYERS
GRAVITY WHEEL CONVEYERS
AUTOMATIC ELEVATORS
GRAVITY ROLLER SPIRALS
GRAVITY SPIRAL CHUTES
POWER PALLET CONVEYERS, Etc.

We have branch offices in all leading American cities with competent engineers in charge. Personal assistance given to architects and engineers in working out handling systems for their clients. We make no charge for this service.

ATTENTION OF MECHANICAL ENGINEERS

Cut out this coupon, attach it to your letter head and we will mail our full set of catalogs and bulletins illustrating and describing the Mathews line of Standard Equipment, consisting of Gravity Conveyers, Automatic Elevators, Gravity Roller Spirals, Gravity Spiral Chutes, etc. Sooner or later you will have use for the information given in our literature.

SPEED · MATHEWS GRAVITY CARRIER COMPANY · The MATHEWS WAY · The SAVING WAY · ECONOMY

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LUNKENHEIMER "DURO" BLOW-OFF VALVE

Exactly what is needed for boiler blow-off purposes.

Self-cleansing seat.

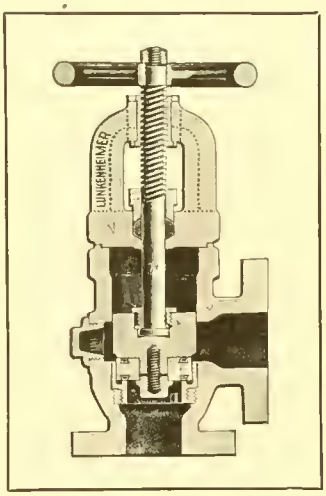
All parts subjected to wear are renewable.

Renewable, reversible disc.

Guaranteed for steam-working pressures up to 250 pounds per square inch.

Made in sizes ranging from 1¼ to 3 inches inclusive.

Specify and insist upon securing genuine **Lunkenheimer make.** Do not accept substitutes—they are never as good as the genuine.



Not an experiment. Tried and tested for a great many years, and has always given perfect satisfaction.

Body and yoke made of a superior grade of cast iron, the tensile strength being 25,000 pounds per square inch.

All parts subjected to wear are made of a high grade bronze composition particularly adapted for the severe usage to which blow-off valves are subjected.

Your local dealer can furnish them; if not, write us.

Write for catalogue.

THE LUNKENHEIMER CO.

"QUALITY"

LARGEST MANUFACTURERS OF HIGH GRADE ENGINEERING SPECIALTIES IN THE WORLD 16-4a

Executive Offices and Factories: CINCINNATI, OHIO, U. S. A.

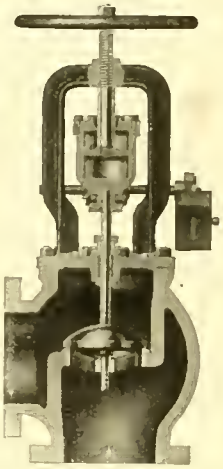
New York, 64-68 Fulton St. | Chicago, 188 N. Dearborn St. | Boston, 138 High St. | London, S. E. 35 Great Dover St.

Consider Well These Features of the Davis Class C Before You Decide Upon the Type of Stop and Check Valve That You Are Going to Use

Service—It will prevent a reverse flow of steam in case of an internal rupture to any one of the boilers in the battery. It isolates any boiler that is not up to the average header pressure.

Dependability—It will not stick. It has an outside oil dash pot. Scale formation or expansion of the parts cannot interfere with its operation.

Indicator—The counter-weight lever moves in unison with the disc. The action of the valve is always visible.



Globe and Angle Patterns

Noiseless—The oil dash pot is effective no matter how small the movement of the disc may be. It cannot pound.

Test—The condition of the internal parts can be easily determined at any time. The counter-weight lever affords means of testing by hand.

Maintenance—The disc and seat may be reground and both are renewable. The stem is packed at the factory with long lived metallic packing.

Send for Descriptive Booklet and List of Users

New York
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Philadelphia

G. M. Davis Regulator Company

439 Milwaukee Avenue, Chicago

Pittsburg
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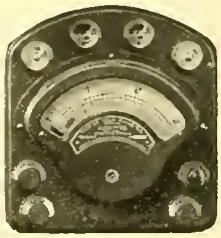
San Francisco

Manufacturers of Valve Specialties Since 1875

WESTON

Miniature Precision Instruments for Direct Current

MODEL 280, Single Range Portable Voltmeter. (One-quarter Size.)



MODEL 280, Triple Range Portable Volt-Ammeter. (One-quarter Size.)

A new group of very small indicating instruments
COMPACT — ACCURATE — DURABLE — BEAUTIFUL

PORTABLE

Voltmeters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters, are supplied in single, double and triple ranges.

The triple range volt-ammeter comprising six instruments in one. This group also includes BATTERY TESTERS

SWITCHBOARD

Voltmeters Volt-Ammeters Ammeters Mil-Ammeters

This new line of instruments represents the latest development of the pivoted moving coil, permanent magnet type for low ranges.

The refinement of design and mechanical work in them has been carried to a degree which would appear to be almost impossible of accomplishment, if the results were not evident in the instruments themselves.

They embody characteristics which have made the well known Weston Standards famous throughout the world.

They are accurate, dead beat and extremely sensitive.

They may be left continuously in circuit at full load without injury and are shielded against the external electrical and magnetic influences of other apparatus in their vicinity.

They are substantially constructed and may be safely sent long distances through the mails and will withstand an extraordinary amount of vibration without injury.

They have the longest scale ever provided in instruments with equal length of pointer.

Each model has been thoroughly tested under the most severe conditions of service and in experiments extending over more than one year.

The portable instruments may be conveniently carried in the coat pocket.

The prices have been established upon so low a scale that any one may possess one or more of these remarkable instruments at moderate cost.

If you cannot obtain the instruments desired from your dealer, write us.

The several models and ranges offer a selection from over 300 different combinations, listed in Bulletin No. 8. Will be mailed upon request.

MODEL 267, Switchboard Ammeter. (One-quarter Size)

MODEL 268, Switchboard Volt-Ammeter. Reads Amperes. Press Button for Volts. (One-quarter Size.)

WESTON ELECTRICAL INSTRUMENT COMPANY,

Main Office and Works: NEWARK, N. J.

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Chicago, 832 Monadnock Block.
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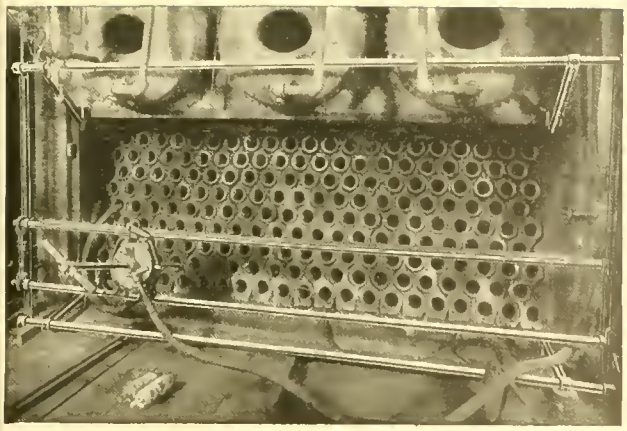


Special arrangement used for supporting the Lagonda Motor Driven Cleaner at the plant of the Colorado Springs Interurban Ry. Co.

Where Others Fail LAGONDA Cleaners Succeed

EXTRA hard and thick scale is the kind that tries out a tube cleaner—that's where some fall by the wayside, but the Lagonda always makes good. You don't believe it?—Then hear what one of our users has to say:

Colorado Springs, Colo., Nov. 26, 1912.
The Lagonda Mfg. Co.,
Springfield, Ohio.

GENTLEMEN:—The steam motor boiler tube cleaner we bought of you has proven to be beyond our expectations. It works perfectly, and removes very thick and hard scale in our B. & W. Boilers.

We have tried about all the other tube cleaners on the market, and with no success, but the Lagonda tube cleaner does the work in quick time.

Our scale is so thick and hard we used a small block and tackle to force the cutter head against the scale.

We can cheerfully recommend the Lagonda Cleaner to any one who is in need of a first-class tube cleaner. Yours truly,

C. E. BIBB,
Supt. & Chief Engr., Power Plant.

The Lagonda Steam Driven Cleaner and 70 others are described in Catalogue "JL" —Ask for a copy.

The Lagonda Mfg. Co.
SPRINGFIELD, OHIO.
FUEL SAVING SPECIALISTS
NEW YORK, BOSTON, PHILADELPHIA, ST LOUIS, CHICAGO, DETROIT, DALLAS, SAN FRANCISCO, ST PAUL, MONTREAL, LONDON

Makers of Weinland Boiler Tube Cleaners, Automatic Cut-off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers. 208

The Diamond Trade Mark Is Your Protection

REG. U.S. PAT. OFF. TRADE JENKINS MARK
Jenkins Bros.

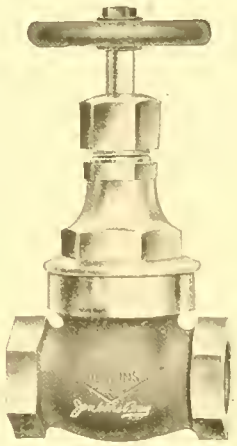
There can be no question about the sound business sense of installing "trade-marked goods" of known standing and quality.

An article which is *not good enough* to be trade-marked, or bear evidence of grade backed by the maker, is not good enough to specify.

Jenkins Bros. Valves are distinguished by their registered trade mark. Specify *Jenkins Bros.* products and you obtain quality and good service.

Jenkins Bros. Gate Valves

Brass Iron Body Cast Steel



The type illustrated this month is the Jenkins Bros. Brass Gate Valve. Particular attention is directed to the *globe shaped body*—a unique and distinctive feature in gate valves, originated by Jenkins Bros. This design secures the greatest possible strength, rigidity, symmetry, and full free opening.

The metal is of the same high grade as used for the Jenkins Bros. Brass Globe and Angle Valves. The valves are all of the solid-wedge, double-face type, therefore simple in construction and free from troubles incident to internal wedging devices.

Made in various styles, stationary spindle, outside screw and yoke, rising spindle, wood wheel, brass wheel, hose end, cap and chain, quick opening; and in Standard, Medium and Extra Heavy Patterns.

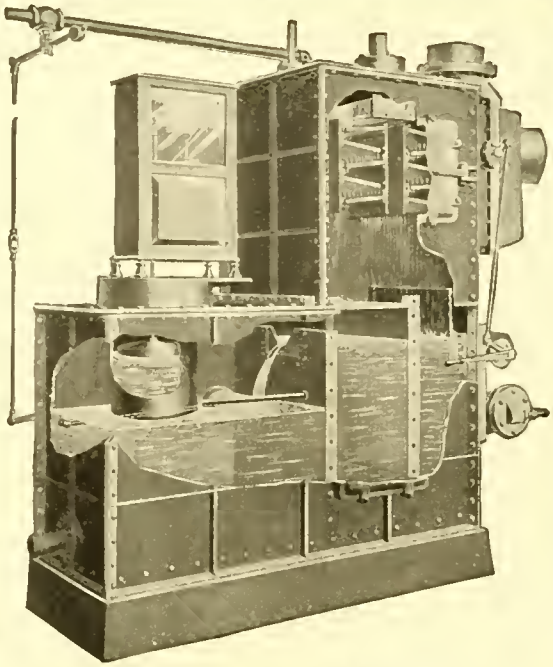
Write for catalogue descriptive of the entire line.

Jenkins Bros.

80 White Street, New York

Boston Philadelphia Chicago

JENKINS BROS., Limited, MONTREAL, P.Q. LONDON, E.C.



Interior View of Cochrane Metering Heater

USE THE COCHRANE METER

IN the Cochrane Metering Heater (Combined Open Feed Water Heater and Hot Water Meter) the metering chamber is a part of the heater structure, under the same back pressure, and where Cochrane Independent Meters are used in connection with open or closed heaters, the same conditions are secured under our patents. There is, therefore, no escape of vapor nor loss of heat.

COMBINING the meter with the heater enables us to utilize the settling chamber of the heater as the still-water or approach chamber for the V-notch weir, saving in space, complication and expense for piping, valves, etc.

THE Cochrane Metering Heater gives greatly superior results in connection with reciprocating boiler feed pumps, as the fluctuations are smoothed out by the storage capacity ahead of and after the weir. With other types of flow meters, the rapid fluctuations of the flow render the chart illegible.

HAVE you read our pamphlet *"Hot Water Meters and Their Practical Application"?*

HARRISON SAFETY BOILER WORKS

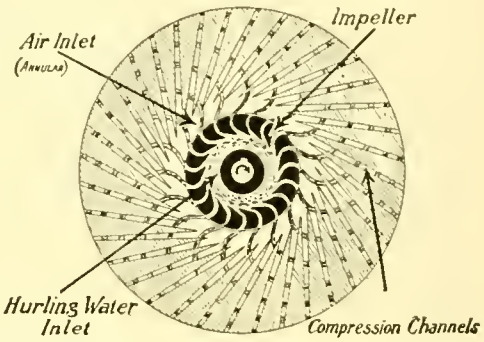
3199 N. 17th St.

PHILADELPHIA, PA.

WHEELER Turbo-Air Pump

A HIGH Speed Rotary Air Pump may have many advantages such as turbine drive, simplicity, oil-free exhaust and small space occupied, but it is very important that the pump selected have high efficiency and large air capacity.

These fundamental advantages are secured with the Wheeler Turbo Air Pump, because the hurling water is discharged in numerous high velocity jets *around the entire periphery of an impeller*, and because air is *positively entrapped* between successive layers of water entering the diffusers.



The design is based on the German type built by the Allegemeine Elektricitaets Gesellschaft. The impeller hurls water in small streams into the diffuser ring whose blades cut the water into a large number of layers, which close the section of the channels and force the entrapped air out against atmospheric pressure. The air enters by a large nozzle connecting to the annular space surrounding the impeller.

WHEELER TURBO AIR PUMPS MAINTAIN 99% VACUUM UNDER ACTUAL WORKING CONDITIONS

Send for Bulletin A. E. 111. Also ask for bulletins on Surface or Jet Condensers, Centrifugal Pumps, Forced Draft and Natural Draft Cooling Towers

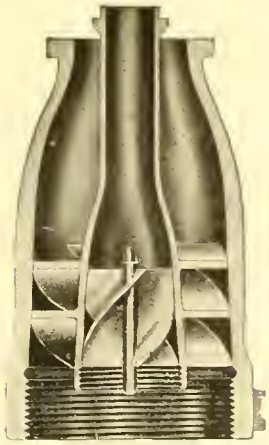
WHEELER

CONDENSER & ENGINEERING CO.

CARTERET, NEW JERSEY.

"Pioneer American Condenser Builders"

113



RE-COOLING CONDENSING WATER

A high vacuum with the least amount of condensing water is only obtained with condensing water of low temperature, and where purchased from the city or the natural supply is limited, the best means of re-cooling the condensing water, cooling the jacket water of oil or gas engines, etc., is by the use of

Recent installation of Koerting Low Pressure Re-cooling Nozzles at the LOUISVILLE COTTON MILLS, LOUISVILLE, KY.

Koerting Low Pressure MULTI-SPRAY NOZZLES

which is a *double effect nozzle.* It breaks the water up into the finest particles, not like inefficient constructions where a full stream of water mixes with atomized water resulting in big drops. The atomization in the Koerting Multi-Spray Nozzle is perfect.

The life of such a spray cooling plant is considerably longer than cooling towers, operation cheaper than cooling towers, and there is little or no cost for repairs.

Write today for a copy of our Catalogue 6-B

SCHUTTE & KOERTING CO.

1239-57 North 12th St. Philadelphia

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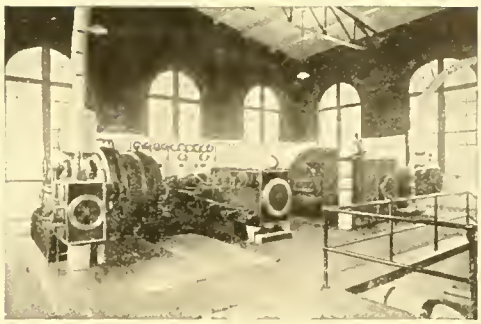
Boston, 132 High St. Pittsburgh, Keenan Bldg.
Denver, 1st Nat. Bank Bldg. Cleveland, New England Bldg.
Kansas City, Burton Machy. Co.



Power Plant Efficiency

is not merely a matter of low first cost or even low steam economy.

An efficient steam engine must be reliable and durable in operation, and economical in the use of steam. A maximum efficiency is not attained when one of these features is developed without regard for the others.

The Ball Non-Releasing Gear Corliss

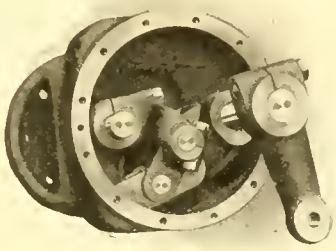
engine attains a maximum efficiency because it combines reliability and durability with steam economy. This is proven by the operating records of the best Isolated Plants in the country. It is the secret of the preference given Ball Engines by discriminating Owners and Engineers.

Are you acquainted with the special features that have made Ball Engines so successful?

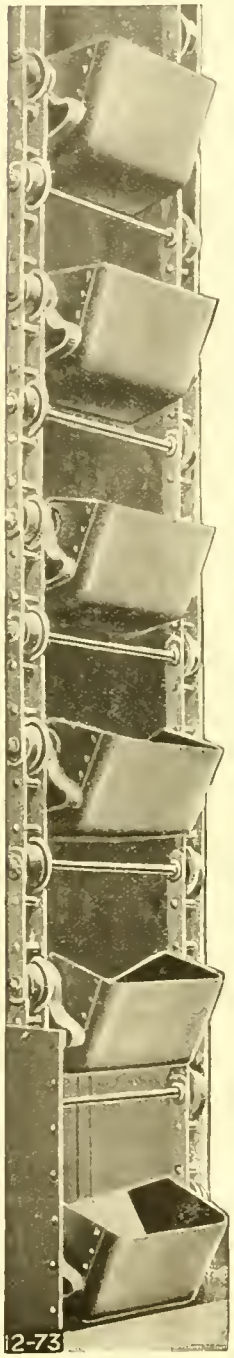
Write for Information

BALL ENGINE CO.

ERIE PENN.



HUNT
Noiseless Conveyors



Vertical line of Conveyor Buckets, showing construction of the chain.

are silently elevating and conveying thousands of tons of coal, fertilizer material, phosphate rock, ashes and even "Tomatoes" in most every part of the world—and doing it so efficiently and with so little "fuss" that in many plants they hardly know such a machine is in operation.

The pawl driver and the large revolving curves, instead of sprocket wheels, at the points where direction of travel is changed, reduce the wear on the machine to such an extent that it is years before repairs are required, provided ordinary care is taken by those in charge.

This Conveyor is made in sizes, and the buckets of material, to suit any conditions. If you have bulk material of *any* kind to handle—tell us your problem and let us help you solve it. Anyway, write for Catalog S-12-9. It's free and it's interesting.

C. W. HUNT CO., Inc.

West New Brighton, N. Y., U.S.A.

45 Broadway, New York City Evans Building, Washington, D. C.
Fisher Building, Chicago, Ill.

Consult the Cowdrey Machine Works——

For the building of your special machine or machine work on a contract basis.

A MODERN SHOP AT YOUR DISPOSAL

The methods and tools we employ in our large up-to-date factory insure rapid production of accurate work at a reasonable cost.

Our forty years' experience in building special machines for knitting mills, paper making, wood working and nearly every other kind of purpose, is also sure to be of service to you.

We gladly submit preliminary estimates from blue prints. Send yours to-day

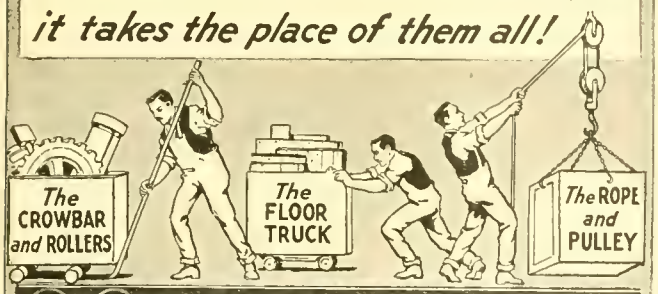
C. H. Cowdrey Machine Works

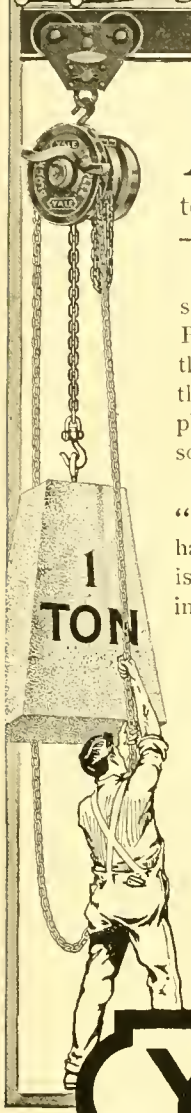
FITCHBURG, MASS.

Contractors, Builders and Designers of Special Machinery

The YALE TRIPLEX BLOCK

it takes the place of them all!





ARE you interested in learning how the Yale Triplex Block can be made a factor in *lowering your production cost* —as well as in saving labor?

We have facts, figures and concrete stories of the value of the Yale Triplex Block that we will gladly send you for the asking. Let us demonstrate what the Yale Triplex Block is daily accomplishing for many concerns—probably some of them in your own line.

The Yale Triplex Block, Model SS, **"From-Hook-to-Hook-a-Line-of-Steel,"** has been on the market six months. It is used for every kind of lifting. And in operation it is quick, easy, safe. It holds the load. Write for our book of Hoists. It tells you all about it.

The Yale Triplex Block is made by the manufacturers of Yale Locks and Hardware.

The Yale & Towne Mfg. Co.

MAKERS OF YALE LOCKS, HARDWARE AND CHAIN HOISTS.

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CANADIAN YALE & TOWNE LIMITED
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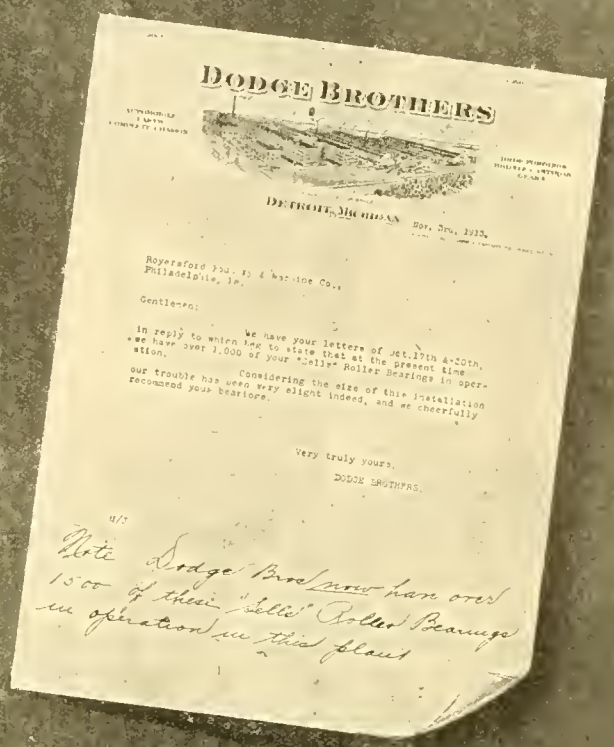
YALE

LOOK FOR THE NAME YALE ON LOCKS AND HARDWARE

You, Too, Can Get Service Like This


DODGE BROTHERS

DETROIT, MICHIGAN

Nov. 3rd, 1923.

Royersford Foundry & Machine Co.,
Philadelphia, Pa.

Gentlemen:

In reply to which we have your letters of Oct. 17th & 20th, we have over 1,000 of your "Sells" Roller Bearings in operation.

Considering the size of this installation our trouble has been very slight indeed, and we cheerfully recommend your bearings.

Very truly yours,
DODGE BROTHERS.

Note Dodge Bros now have over 1500 of these "Sells" Roller Bearings in operation in this plant

"Sells" Roller Bearings

always give maximum service, as hundreds of letters like this show, and reduce line shaft friction from 25 to 50% or more, because their structural features, —clear in the picture—have taken into account, every retarding and wearing element. Easy application and inspection is assured by the fact that **every part** of bearing is **split.** The record of these bearings in other plants is a guarantee of service "like this" for you. Write now for **Facts** on Commercial Roller Bearings, Power Transmission Machinery, Grinders, Punches and Shears.

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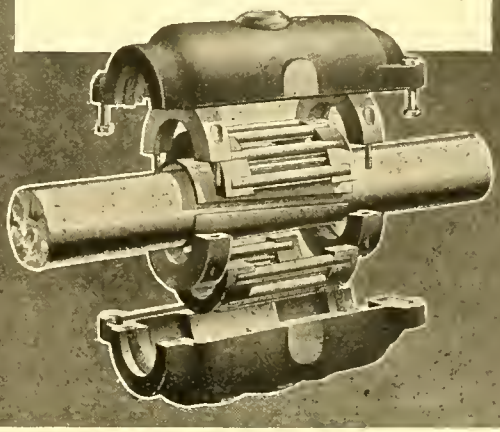

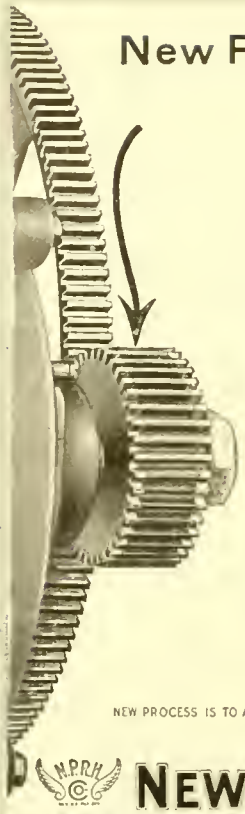

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Motor Pinions

Thoroughly modern equipment, the world's largest plant and 25 years' experience qualify us to produce the best noiseless pinions. We're always ready to quote on any number. Made in many types and sizes. Free engineering service to prospective customers.

Send your blue print for estimate

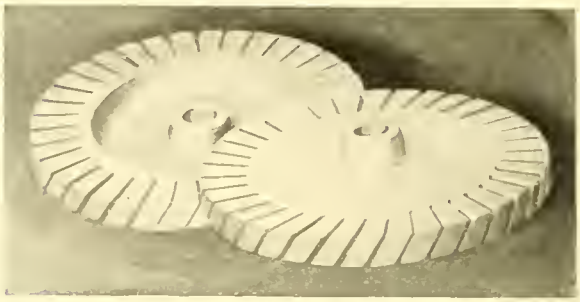
NEW PROCESS IS TO ALL OTHER RAWHIDE AS STEEL IS TO IRON

NEW PROCESS GEAR CORPORATION
SYRACUSE, N.Y

CANADIAN AGENTS: Robert Gardiner & Son, Ltd., Montreal 84

Franklin Die Cast Parts

Are the Standard for Quality



Successful die-casting is a question of experience, study and organization.

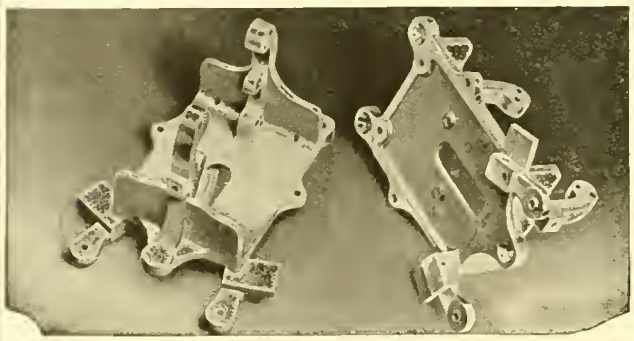
Franklin die-castings are the development of twenty years' successful manufacture.

The Franklin factory affords ample facilities for the meeting of your die-casting requirements.

Franklin quality is the best guarantee of satisfaction.

Let us send you our Booklet "B," which tells what Franklin experience means in furnishing die-cast parts that are right.

Franklin Manufacturing Co.
404 South Geddes Street Syracuse, N. Y.



Doehler Die Castings Offer a Highly Desirable Saving In Production Costs

Getting us to make your Die Castings does away with idle machines, idle space and idle time, lessens opportunity for labor troubles, saves worry and assures the most accurate, uniform and otherwise satisfactory parts that can be produced.

You order and get what you need when you need it and you dodge expense or inactive capital while you are *not* using any castings.

For prompt advice or quotations, send us your blue prints and specifications.

DOEHLER DIE-CASTING CO.
COURT & NINTH STS.
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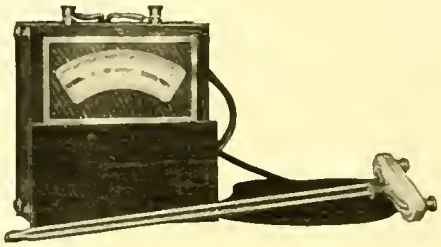
3

Brown Pyrometers



Meet every requirement in the measurement of temperatures up to 3600° or as low as —200°. Brown High Resistance Pyrometers are unaffected by the length of wire connecting the thermo-couple and indicator. Our 56-page Catalogue describes other advantageous features.

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On the Road to Efficiency

One of the milestones on the road to efficiency is the use of

TEXACO LUBRICANTS

The engineer specifying Texaco Lubricants makes long strides towards this goal. He then has lubricants working for him that are fitted to meet his strongest demands.

There are more reasons to make the use a necessity for efficient operation than we can put on this page.

Some of them are—their lubricating and staying qualities, the ease with which they separate from water, their exact suitability to particular requirements, the manner in which they eliminate "trouble"—and, to come to an end here,—the high degree of satisfaction that they are giving to Texaco consumers—and some of these are among the largest plants in the country.

Let their experience at least put you on the road to a trial of "the oils that cost less because they save more."

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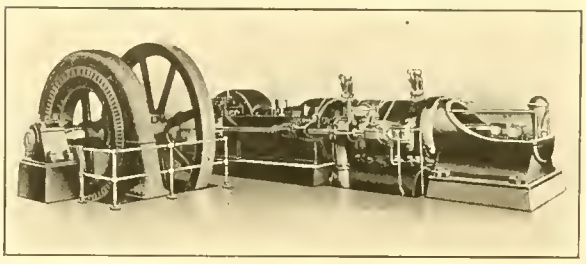
OIL-BURNING ENGINE

is the newest, simplest and most economical prime mover in the world.



STANDARD SIZES 300 to 600 B. H. P.

Operates on the Diesel principle with a guaranteed fuel consumption not in excess of 7½ gallons of crude or refuse oil per 100 B. H. P. hours.

Let us send you descriptive matter covering details of construction and operation.

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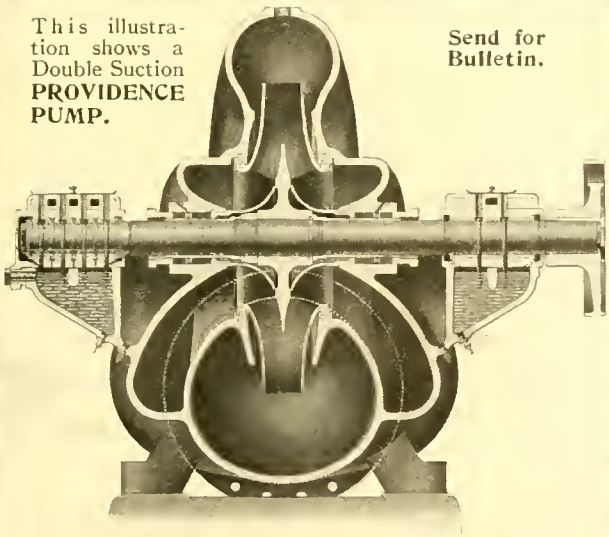
Manufactured By
THE BROWN ENGINE CO., Fitchburg, Mass.

This illustration shows a Double Suction **PROVIDENCE PUMP.**

Send for Bulletin.



PROVIDENCE PUMPS

are built for all purposes in capacities of 100 to 100,000 gallons per minute.

Double Suction Pumps for moderate heads.

Stage Pumps for greater heads or pressures.

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Providence, Rhode Island

C. H. Wheeler Condensers

We guarantee our apparatus to maintain a vacuum as close to absolute as is commercially possible, and with the lowest operating and maintenance cost.

The C. H. WHEELER "High Efficiency" System of Steam Auxiliaries includes:

- C. H. WHEELER High Transmission Surface Condensers.
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Friction Clutch Pulleys
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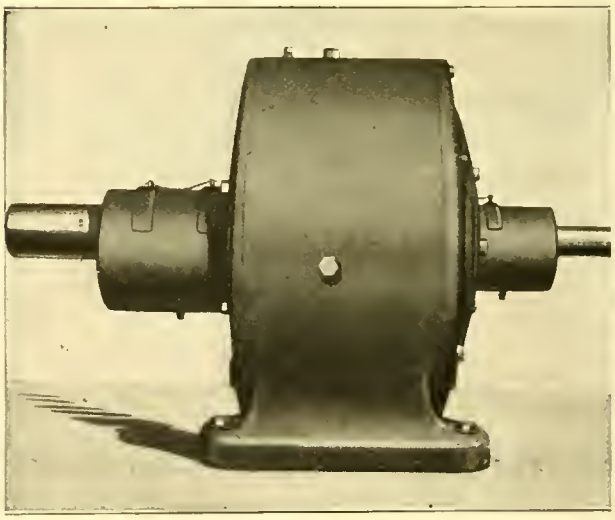
Ratio 4:1 up to 1600:1 or more
Made in Any Horse Power, Any Ratio



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No { Undesirable Belts / Troublesome Chains / Exposed Gearing

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Established 1888

1120-22 W. Monroe St. CHICAGO

CUT GEARS OF EVERY DESCRIPTION
WE MAKE INCASED WORM GEAR REDUCERS

SPRAGUE ELECTRIC

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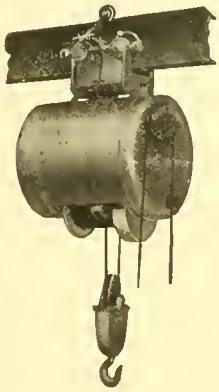
Capacities from 1-2 to 6 Tons
A.C. and D.C.



ELECTRIC MONORAIL CRANES
ELECTRIC WINCHES
ELECTRIC SHOVELS

DIRECT CURRENT GENERATORS

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VENTILATING EQUIPMENTS

Write for Descriptive Pamphlet No. 23360

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OF GENERAL ELECTRIC COMPANY
Main Office: 527-531 West 34th Street
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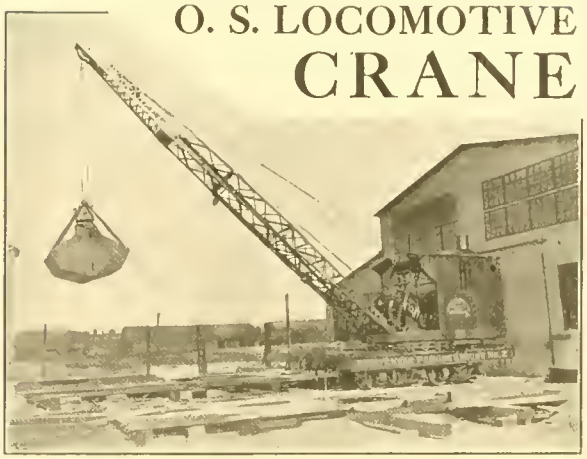
The Proper Machine for General Erecting Purposes

O. S. LOCOMOTIVE CRANE



15 Ton Radial Truck Crane with Fall Block and Bucket

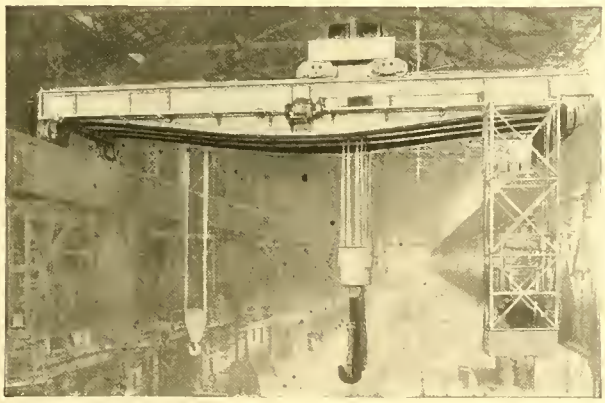
Seven of these machines purchased by the United States Government.

Built for standard or broad gauge track, 4 wheel or 8 wheel car body, full steel cab or steel canopy only and with any special equipment, such as pile driver leads, steam shovel attachment, etc.

Bulletin No. 9 gives full details

ORTON & STEINBRENNER CO.
Material Handling Machinery
Main Office: CHICAGO, ILL.

"ALLIANCE" FOUR GIRDER LADLE CRANE

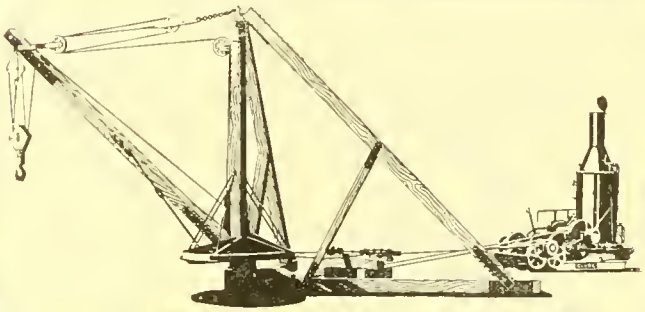


The cut shows one of the three 150-ton Ladle Cranes installed in the works of a large steel company. This crane represents the very latest construction for ladle cranes (we have built 125 of this type), and has seven distinct and important advantages over the old type of crane. In fact so important are these advantages that the old type of crane has become obsolete. We have built these cranes in capacity from 175 tons down to 30 tons. The 175 ton cranes are the largest of their kind in the world.

PITTSBURG *The Largest Manufacturers of the World's Largest Cranes* NEW YORK

THE ALLIANCE MACHINE CO.
ALLIANCE, OHIO.
ENGINEERS AND BUILDERS

BIRMINGHAM CHICAGO



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TRADE CLYDE MARK

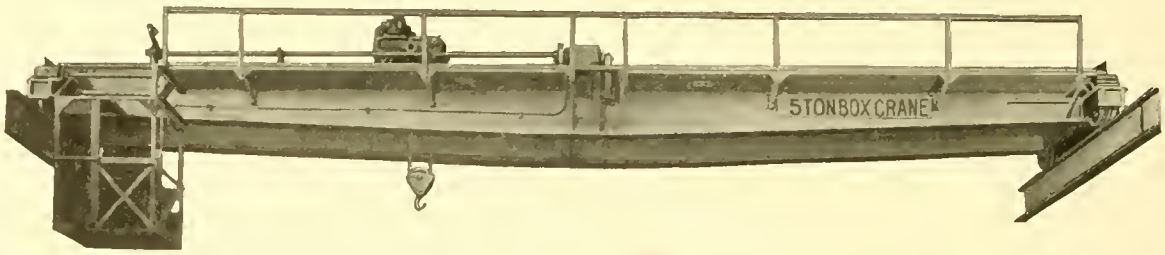
It is the mark of *guaranteed efficiency* thruout the field of

HOISTS AND DERRICKS

We build a repeat order into everything of CLYDE GRADE, making *our machines* our best advertisements and salesmen

CLYDE IRON WORKS
HOME OFFICE & FACTORY
DULUTH, MINNESOTA, U.S.A.
MANUFACTURERS OF CLYDE GRADE LOGGING HOISTING AND EXCAVATING MACHINERY.

ELECTRIC & HAND POWER CRANES, PORTABLE ELECTRIC & MONORAIL HOISTS



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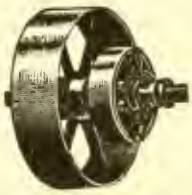
ENGINEERS, FOUNDERS, MACHINISTS AND MILLWRIGHTS



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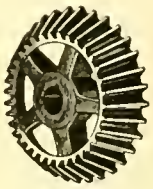
DESIGNED, FURNISHED AND ERECTED

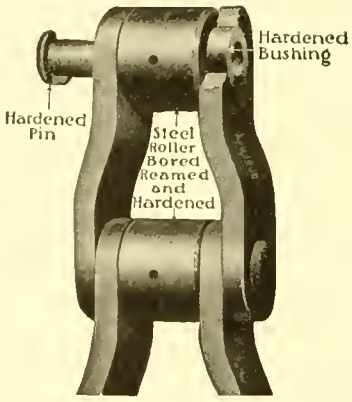


Gears of all kinds and sizes

SPECIAL MACHINERY IRON CASTINGS

WORKS: ELIZABETHPORT NEW JERSEY

SALES ROOM: 79 BARCLAY ST. NEW YORK CITY



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The wear is confined to renewable bushings and pins (Hardened by the new J-Co. Process), the outside chain links being held rigidly secure to the pins and the inside links to the bushings.

A Strong, Serviceable drive chain for elevating, conveying and transmission purposes.

Made in sizes to work on our many Standard Sprocket Wheels.

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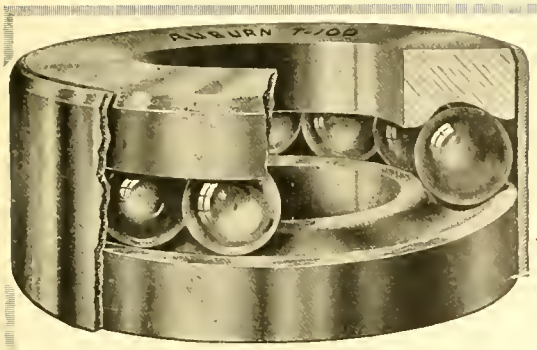
The Fellows Gear Shaper Co.

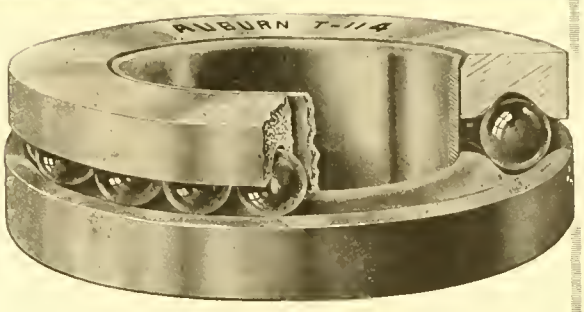
23 Pearl Street, Springfield, Vermont, U. S. A.



THRUST TROUBLES OVERCOME

Auburn Trade Mark

Rochester, N. Y.



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reduce wear and tear, stop lost motion, greatly cut down oil consumption and eliminate time out for renewals when used for taking end thrust of shafts and other rotating parts. State your difficulties, or ask for bulletins. STEEL, BRASS AND BRONZE BALLS.

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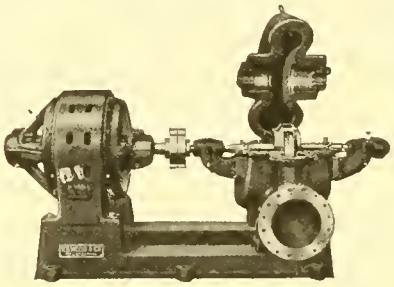
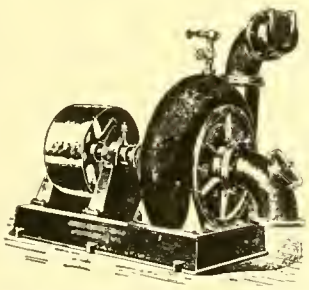


CENTRIFUGAL PUMPING MACHINERY



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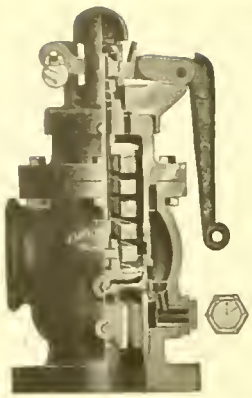

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All of a superior quality and guaranteed to give greatest efficiency, durability and perfect satisfaction. Backed by a reputation secured in 42 years of successful business.

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STEAM SUPERHEATERS — MECHANICAL STOKERS

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For Water Tube and Tubular Boilers

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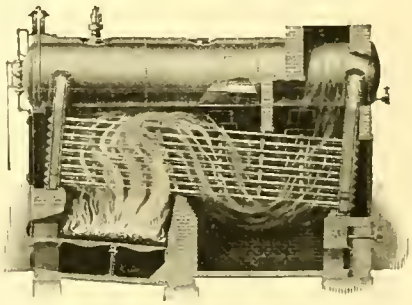

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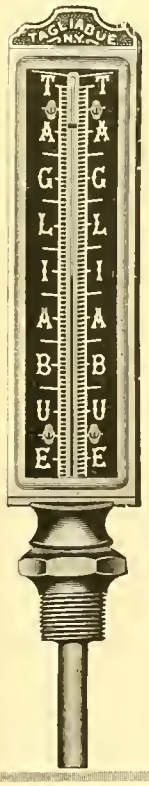

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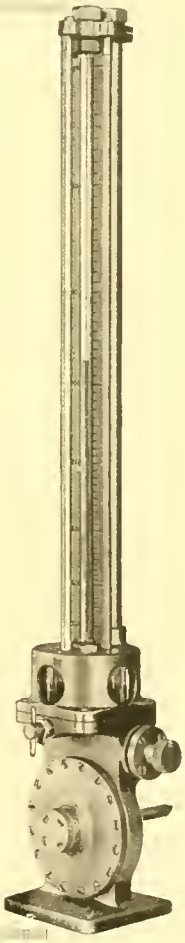

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Builders of Ball Single Valve Automatic and High Speed Corliss Engines with non-detaching valve gear, for direct connection, or belting to electric generators.

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Builders of the Edge Moor Water Tube Boiler. Especially suitable for large power plants. Steel construction, straight tubes, all hand holes elliptical, unrestricted circulation which permits forcing fires with safety and economy.

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Manufacturers of Fleming-Harrisburg Horizontal Engines, Corliss and Single Valve, Simple, Tandem and Cross Compound.

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HEINE SAFETY BOILER CO.

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Heine Safety Water Tube Boilers, Heine Patent Steam Superheaters, Steel Stacks, Housings, Flues, etc.

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Manufacturers of Hamilton Corliss Engines, Hamilton High Speed Corliss Engines, High Duty Pumping Engines, Power Pumps and Compressors, Special Heavy Castings.

See pages 6, 7, 309 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Engines

Pumps

Compressors

Castings

Boilers

E. KEELER COMPANY

WILLIAMSPORT, PA

Water Tube, Internal Furnace and Return Tubular Boilers. Self-Supporting Stacks, Feed Water Heaters.

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Special Machinery

PROVIDENCE ENGINEERING WORKS

PROVIDENCE, R. I.

Rice and Sargent Corliss Engines, Providence Centrifugal Pumps, Improved Greene Engines and repair parts, Special Machinery.

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Builders of Corliss Engines, Girder or Heavy Duty Type Bed for Belted or Direct-Connected Service, medium or high speed. Ice and Refrigeration Machines.

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Refrigerating and Ice Making Machinery, 5 to 600 tons capacity; Oil Engines up to 360 B. H. P.; Gas Engines 75 to 2400 B. H. P.

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Builders of Smith Automatic Gas Producers, both suction and pressure types. Mechanically Operated Gas Producers in large units for power and heating plants. Tar Extractors and Gas Cleaning Plants.

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Manufacturers of Pressure Reducing Valves, Back Pressure Valve, Steam Trap, Exhaust Relief Valves, Balanced Valve, Float Valve, Pump Governor, Boiler Stop and Check Valves.

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Complete Condensing Plants for High Vacuum; Counter Current, Jet and Surface Condensers, Air Pumps, Pumping Outfits, Re-Cooling Plants. Oil, Air and Steam Separators. Combined Oil Separators and Heaters. Dry and Wet Air Filters. Air Extractors for Feed Water ("Airex"). Return and Vacuum Steam Traps.

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Engines

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Fuel Economizers; Waste Air Heaters; Fans, Blowers and Exhausters; Engines; Positivflow Hot Blast Heaters, Drying Equipments; Heating and Ventilating Equipments, Mechanical Draft Installations.

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Separators
Metering Heaters

HARRISON SAFETY BOILER WORKS

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Cochrane Feed Water Heaters, Cochrane Steam and Oil Separators, Sorge-Cochrane Hot Process Softening Systems, Cochrane Multiport Valves, Cochrane Metering Heaters.

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Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most difficult service for water, air or steam. Valves unlike all others.

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Manufacturers of Regulating Valves for all pressures and for steam, air and water. The best and only absolutely noiseless Combination Back Pressure and Relief Valve. Pump Regulators, Separators, Steam Traps, Automatic Stop and Check Valves. Write for complete catalogue.

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Makers of Weinland Tube Cleaners, Automatic Cut-Off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers.

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Cut-Off Valves

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Manufacturers of genuine Ludlow Gate Valves for all purposes. Special Blow-off Valves. Check Valves. Foot Valves. Sluice Gates. Indicator Posts. Fire Hydrants.

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THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

Manufacturers of high-grade engineering specialties, comprising Brass and Iron Valves, Whistles, Cocks, Gauges, Injectors, Lubricators, Oil Pumps, Oil and Grease Cups, etc., adapted to the requirements of all classes of machinery.

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Return, Non-Return, Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

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Builders of The Murphy Automatic Furnace. The best Automatic Furnace that thirty years practical experience can produce.

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Manufacturers of high grade Bronze, Iron and Steel Valves of every kind for every purpose.

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Valves

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Governors for Steam Engines, Turbines, Gas Engines. Mechanical Control Power Regulation.

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Governors

POWER SPECIALTY CO.

111 Broadway NEW YORK

The Foster Patent Superheater saves feed water, condensing water, coal and boiler power.

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NATIONAL PIPE BENDING CO.

NEW HAVEN, CONN.

National Feed-Water Heaters, National Storage Heaters, National Direct Contact Heaters and Purifiers, National Steam and Oil Separators. Coils and Bends of Iron, Brass and Copper Pipe.

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Feed-Water Heaters and Purifiers

Separators

Valves

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BRANCHES AT ALBANY, BALTIMORE, BOSTON, CHICAGO DETROIT, INDIANAPOLIS, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURG.

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THE SIMS COMPANY

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Designers and Manufacturers of Steam Specialties and Power Plant Appliances: Closed Feed Water Heaters, Open Feed Water Heaters, Hot Water Generators-Convertors, Laundry Heaters, Live Steam and Water Mixers, Exhaust Heads, Oil Extractors, Oil Filters, Compound Feeders, Garbage and Refuse Burners, Tanks.

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Manufacturers of Instruments for Indicating, Recording and Controlling Temperature and Pressure. Thermometers; Automatic Controllers; Gages; Oil Testing Instruments; Engineers' Testing Sets, Pyrometers, Barometers, Hygrometers, Hydrometers, etc.

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THE TEXAS COMPANY

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Lubricating Oils for Power Plants, Central Stations, Machine Shops, Foundries and all general purposes. All classes of Petroleum Products of the highest quality.

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WHEELER CONDENSER & ENGINEERING CO.

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Surface, Jet and Barometric Condensers, Combined Surface Condensers and Feed Water Heaters, Cooling Towers, Edwards Air Pumps, Centrifugal Pumps, Rotative Dry Vacuum Pumps and Multiple Effect and Evaporating Machinery.

See page 66, 67 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Condensers

Cooling Towers

Feed-Water Heaters

C. H. WHEELER MFG. CO.

PHILADELPHIA, PA.
NEW YORK BOSTON
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Manufacturers of High Vacuum Apparatus, Condensers, Air Pumps, Feed-Water Heaters, Water Cooling Towers, Boiler Feed and Pressure Pumps.

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Water Meters

Blow-off Valves

Pipe-Joint Clamps

YARNALL=WARING CO.

CHESTNUT HILL PHILADELPHIA, PA.

Manufacturers of the "Lea" V-Notch Recording Meter, Simplex Seatless Blow-off Valve and the Simplex Pipe-Joint Clamp.

See page 95 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves

Power Plant Piping

Wrenches

WALWORTH MANUFACTURING CO.

BOSTON, MASS.

Manufacturers of high grade Brass, Iron and Steel Valves; Power Plant Piping; Screwed and Flanged Fittings; Pipe Fitter's Tools; Genuine Stillson Wrenches, Parmelee Wrenches, Walco-Hex Wrenches.

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Ball Bearings

Auburn Four Point Contact Cone Principle Ball Thrust Bearings, Auburn Special Ball Thrust Bearings, Auburn Steel, Brass and Bronze Balls, Solid and Hollow.

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79 BARCLAY ST. NEW YORK

Shafting
Pulleys
Hangers

Manufacturers of Shafting, Pulleys, Hangers, etc., for Transmission of Power.

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DODGE MANUFACTURING CO.

MISHAWAKA, IND.

Power Transmission
Elevators
Conveyors

Manufacturers of everything for the Mechanical Transmission of Power; also Elevating and Conveying machinery, and the "Eureka" Water Softener. Our new catalog 106A14 gives an idea of the Dodge line.

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Ball Bearings

High grade Ball Bearings made of the finest materials to the closest standards of accuracy in the world. Fafnir Ball Bearing Hanger Boxes can be used in any standard hanger frame.

FALLS CLUTCH & MACHINERY CO.

CUYAHOGA FALLS OHIO

Power Transmission Appliances

Friction Clutch Pulleys, Couplings, Quills, Operators, Clutch Sheaves, Floor Stands, Heavy Mill Bearings, Shaft Couplings, Sheaves and Tension Carriages, Pulleys and Fly Wheels.

See page 149 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

THE HILL CLUTCH COMPANY

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Power Transmission

Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

See page 156 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

D. O. JAMES MANUFACTURING CO.

1120-22 W. MONROE ST. CHICAGO

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Speed Reducing Transmissions

Specialists in cut gearing; spur, spiral, bevel, mitre, worms and worm gears, rawhide pinions, racks, incased worm gear reductions, O'K speed reducing transmissions 4:1 up to 1600:1.

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Manufacturers of New Process Noiseless Pinions and also of accurately cut Metal Gears of all kinds.

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Tanners and Manufacturers of Oak Tanned Leather Belting, Round Belting, Lace Leather, Belt Leather, Welting, Strapping, Finished Oak Shoulders, Slabs, Bellies, Scrap Leather.

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Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MAY · 1914

SPRING MEETING, ST. PAUL-MINNEAPOLIS
JUNE 16-19

COÖPERATION

THIS is the national society of the mechanical engineering profession,—in fact, it is *the Society of the industries*, and every engineer in the industrial world should aim to be numbered among its members.

The Society has adopted a broad and liberal policy and aims to do everything possible for each engineer both with regard to the special branch of the profession in which he is engaged and to the geographical section of the country in which he is located. Provision is made for the former by the establishment of committees composed of recognized authorities in the specialty which they represent. Geographical sections are being formed in all of the industrial centers of the country so that practically every member may now enjoy at frequent meetings the opportunity to discuss technical problems, and by the presentation of papers, researches and reports and the free interchange of ideas obtain a standardization of engineering practice.

Not only is the Society doing all that is possible through its own avenues, but it coöperates with other engineering organizations in their undertakings, all aiming to promote the arts and sciences.

The members residing in the Middle West should see that the interest of every engineer in that large territory is aroused in the Spring Meeting of the Society which will be held at St. Paul—Minneapolis, June 16-19. This meeting offers an opportunity to extend the courtesies of the Society to your friends and associates. Send their names and addresses to the Secretary and an invitation to the meeting and other information will be forwarded to them in your name. The program, both professionally and socially, promises to be unusually interesting and is worthy of the personal interest and support of all members.

Total Membership of the Society, April 15, 1914 ..... *5512*
New Members since January 1, 1914 ..... *141*

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 MAY 1914 Number 5

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C 55 The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

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COMING MEETINGS OF THE SOCIETY

May 1, *New Haven, Conn.*, Mason Laboratory, Sheffield Scientific School. Quarterly meeting with sessions at 3 p.m. and 8 p.m. Subject, Afternoon Session, Aeronautics and the Internal-Combustion Motor; Papers: A Review of Aeronautical Progress, by John J. Long; Automobile and Aeroplane Motors, by David L. Gallup; Fuels for Internal-Combustion Engines, by D. B. Pangburn; Connecticut Aeroplane Company, by Everard Thompson. Subject, Evening Session, Aeronautics; Address by James Hartness; Papers: The Evolution and Status of Aeronautics, by Henry Woodhouse; Representative American Aeronautical Motors, by Howard Huntingdon. See p. V.

May 5, *San Francisco, Cal.* Subject: Stationary Diesel Engine Operation using California Fuel Oil.

May 12, *New York City*, Engineering Societies Building. Paper: Plans for the Main Drainage and Sewage Disposal for the City of New York, by H. deB. Parsons. Illustrated by lantern slides. Mr. Parsons, who is a member of the Metropolitan Sewerage Commission, will discuss the work of the commission and its plans for the protection of the various drainage divisions of the city.

May 13, *Boston, Mass.*, Engineers Club. Topic, Boiler Room Practice, discussed by Capt. Chas. H. Manning and other well-known engineers.

May 13, *Chicago, Ill.*, Hotel Sherman. Dinner meeting. Subject: Machine Shop Practice.

June 3, *St. Louis, Mo.*, Engineers Club. Paper: Oil Engines with Special Reference to Fulton-Tosi Oil Engines, by H. R. Setz. Illustrated by lantern slides.

Spring Meeting, June 16–19, *St. Paul-Minneapolis.* See pp. III and IX.

THE JOURNAL OF

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THE SPRING MEETING

THE program for the Spring Meeting in St. Paul, Minneapolis, June 16-19, has been practically completed by the Committee on Meetings and the local committee, and offers many attractive features. Some views showing the picturesqueness of the two cities to be visited and a description of their many interests was published in the April issue, and in another page of this issue appears an account of the points of engineering importance, as well as some description of Duluth to which a side-trip will be made following the close of official meeting.

The social features which add so much to a meeting of this sort, especially at a time of year when the strain of the winter's work makes all desire relaxation and change, will be prominent, due to the good work of the local committee, and it is expected that the entire program will be thoroughly enjoyed. An outline of the events planned follows:

TENTATIVE PROGRAM

Tuesday, June 16, St. Paul

Opening of headquarters and registration.

5.00 p.m. Council meeting.

8.30 p.m. Reception.

9.30 p.m. Introductory remarks by James Hartness, President of the Society, followed by a message to the Engineering Fraternity, especially the mechanical engineering profession, by James J. Hill, former president of the Great Northern System. Welcome to Minnesota by Governor A. O. Eberhardt.

10.00 p.m. Dancing and refreshments.

Wednesday, June 17, St. Paul

10.00 a.m. Business meeting. Proposed amendments to the Constitution and announcement of ballot on amendments to C-9 and C-11. Report of Committee on Flanges.

PROFESSIONAL SESSION

Papers and a topical discussion on the subject of Powdered Fuel.

During the morning the ladies will be shown about the city and will be entertained at luncheon.

12.00 m. Conference luncheon for members of Council with representation of the local committees and sections.

Wednesday Afternoon

MISCELLANEOUS SESSION

INDUSTRIAL SERVICE WORK IN ENGINEERING SCHOOLS, J. W. Roe.

CLASSIFICATION AND HEATING VALUE OF AMERICAN COAL, Wm. Kent.

THE RAILROAD TRACK SCALE, W. W. Boyd.

GEAR TESTING MACHINE, Wilfred Lewis.

A NEW FLOW METERING APPLIANCE, A. M. Levin.

Wednesday Evening

8.15 p.m. Lecture on IRON ORE HANDLING, with moving pictures, by John Hearding, superintendent, Oliver Iron Mining Company, Duluth.

Thursday, June 18, Minneapolis

9.15 a.m. Leave for Minneapolis by trolley.

PROFESSIONAL SESSION, 10.00 A.M.

Meeting in the main engineering building, University of Minnesota, Minneapolis. Opened by an address by a member of the engineering faculty.

A series of papers on engineering developments in the vicinity of St. Paul and Minneapolis will be presented.

During the morning the ladies will be shown about Minneapolis in automobiles.

Thursday Afternoon

12.00 m. Luncheon at the University Building.

1.30 p.m. Members and guests leave by trolley for Excelsior, where the boat will be taken across Lake Minnetonka to the home of Mr. Gebhard Bohn. Mr. Bohn has a beautiful estate of about 20 acres. Supper will be served, followed by dancing.

10.00 p.m. Party will leave by train, due in Minneapolis at 10.30 and in St. Paul at 10.45.

Friday, June 19, St. Paul-Minneapolis

Technical excursions in St. Paul and Minneapolis.

2.00 p.m. Council meeting.

2.30 p.m. Trip to Duluth. On arrival at 6.30 p.m., the party will be received by local members and given an opportunity on Saturday to see the Duluth harbor.

PROFESSIONAL PAPERS

Those desiring advance copies should notify the Secretary

There are to be three professional sessions at the St. Paul-Minneapolis meeting, as listed in the program. The first session will follow immediately after the business meeting on Wednesday morning, June 17, at St. Paul, with papers and a topical discussion on the subject of Powdered Fuel. The papers will relate to the recent development in the use of powdered fuel in the cement industry, in the industrial furnaces and for the generation of steam.

On Wednesday afternoon will be a miscellaneous session with the following papers: Industrial Service Work in Engineering Schools, J. W. Roe; Classification and Heating Value of American Coal, Wm. Kent; The Railroad Track Scale, W. W. Boyd; Gear Testing Machine, Wilfred Lewis; and a New Flow Metering Appliance, A. M. Levin.

On Thursday morning at Minneapolis will be the final professional session with four papers on engineering developments in the vicinity of St. Paul and Minneapolis, treating of the following subjects: The High Dam between St. Paul and Minneapolis; Flour Milling and Flour Mills; Coal Handling; and the Gasolene Electric Car as operated on the Minneapolis, St. Paul, Rochester and Dubuque Electric Traction Company Line (so-called Dan Patch).

Abstracts of all the papers assigned for the Spring Meeting will be published in The Journal for June. *Complete copies of the papers will be mailed to members upon application to the Secretary.* It is expected that these will be ready in pamphlet form about June 1.

TRANSPORTATION

It has been arranged to have a special train convey the members from Chicago to St. Paul, over the C. B. & Q. R. R., leaving Chicago Monday evening, June 15, at 10.45, and arriving in St. Paul at 3.30 on Tuesday afternoon. This train will have a very high grade of equipment, combining safety and comfort with punctuality. There will be standard drawing room and compartment sleeping cars and a large steel dining car, lighted by concealed indirect lighting and having many new and unusual conveniences, will be attached. The train will also include a lounge-observation car of luxurious type, with smoking room and buffet annex, large lounging parlor, writing alcove and library. At the rear of the car is a sun parlor having broad plate glass windows which may be removed in a short space of time, creating an open car. The train will be electric lighted from the head end by a 64-volt, 25-kw. Curtis turbo-generator, which will be in charge of an expert who will demonstrate its operation. A dynamometer car in full operation will be attached to the train, showing how the various tests records on railroads are taken automatically.

Three stops en route have been planned. The first of these will be made at De Soto, Wis., on Tuesday morning, from 6.30 to 7.30, for the observation of the rebuilding and double tracking now being done on this line. Much of the work is being accomplished by a dredging process never before used, and one of these dredges in operation, working from the river to the railroad, will be seen at this point.

At Grand Crossing, Wis., another stop will be made from 8.55 to 9.40 a.m. Here a large non-articulated locomotive will be on exhibition, said to hold the record for economical operation. Part of its equipment consists of an automatic stoker.

At a quarter past eleven the train will make a stop for three hours at Pepin, Wis., to enable the party to enjoy the beauties of Lake Pepin, which is a natural broadening of the Mississippi River, 22 miles long. Among the events planned are motor boat rides on the lake and short automobile tours into the surrounding country. A large government pier located on the lake will also be of interest.

For the assistance of members who will attend the Spring Meeting from the East, the following schedule of trains which will insure connections with this special train at Chicago is offered:

N. Y. C. & H. R. R. R. CO.

Lv. New York..	6.45 p.m.	Arr. Chicago..	5.00 p.m.	Fare, $25
Lv. New York..	2.00 p.m.	Arr. Chicago..	5.00 p.m.	Fare, $20
Lv. New York..	5.00 p.m.	Arr. Chicago..	2.00 p.m.	Fare, $26

P. R. R. CO.

Lv. New York..	2.06 p.m.	Arr. Chicago..	5.00 p.m.	Fare, $20
Lv. New York..	5.04 p.m.	Arr. Chicago..	2.00 p.m.	Fare, $26
Lv. New York..	6.04 p.m.	Arr. Chicago..	8.54 p.m.	Fare, $20

For a party of ten or more a reduction of $1.85 on the fare quoted will be made. The cost of sleeping reservations on any of these trains is at the rate of $5 for the lower and $4 for the upper berths.

The Pennsylvania Railroad lands its passengers in Chicago at the Union Station, from which the trains on the C. B. & Q. R. R. start.

The fare from Chicago to St. Paul will be $8.15, and $2 for sleeping berths.

LANTERN SLIDES

The lantern slides descriptive of the Society's trip to Germany last summer, which were used in connection with Mr. Worcester R. Warner's lecture at the Annual Meeting dinner, are available for use by the membership upon application to the Society's headquarters.

There are also about fifty slides showing views of the Engineering Societies Building which may be borrowed by local sections or student branches which desire to present them before a meeting.

QUARTERLY MEETING AT NEW HAVEN

Aeronautics is to be the main topic of the quarterly meeting at New Haven on May 1, which will as usual be held in the Mason Laboratory of Mechanical Engineering of Sheffield Scientific School. At the afternoon session, commencing at 3 o'clock, when Aeronautics and the Internal Combustion Motor will be considered, John J. Long of Brown University will give an illustrated Review of Aeronautical Progress, followed by three papers, one by Prof. D. L. Gallup of Worcester Polytechnic Institute, another on Fuels for Internal Combustion Engines, by D. B. Pangburn of Sheffield Scientific School, and a third by Everard Thompson of New Haven, on the Connecticut Aeroplane Company. A demonstration of aeroplane motors in the Mason laboratory, given by E. F. Gallaudet of Norwich, Conn., will conclude the session. Dinner will be served at 6 o'clock in the Yale Dining Club, and the evening session will commence at 7.30. President Hartness will open the meeting with an address, and two papers will be presented, The Evolution and Status of Aeronautics, by Henry Woodhouse, Editor of Flying, and Representative American Aeronautical Motors, by Howard Huntingdon of New York.

COUNCIL NOTES

At a special meeting of the Council on April 10, formal approval was voted in the interest of the public of the appointment of engineers, qualified by training and experience, on public service commissions and as heads of engineering departments in national, state and city governments, in accordance with the report of the Public Relations Committee and Alfred Noble. The committee in its report stated that experience had shown engineering training and special knowledge of and experience in organization to be an essential equipment, in addition to business capacity and tact, for the efficient discharge of such duties.

The following Committee on Meetings in Philadelphia was approved: H. E. Ehlers, Chairman, W. R. Jones, Secretary, George R. Henderson, R. H. Fernald, Hugo Bilgram and D. R. Yarnall.

Alex. C. Humphreys and E. D. Meier were chosen as representatives of the Society on the Joint Reception Committee to arrange for the reception of engineers in connection with the International Engineering Congress of 1915.

It was voted to appoint a committee to consider and report its recommendations for the standardization of pipe threads for gas and electric fixtures and conduit fittings, supplementing the important work of the International Committee on Pipe Threads.

Notice was given of the purpose to amend By-Law 2 regarding requirements for references for applicants for membership. When an applicant is residing where there are not five members, then members of other professional societies of similar standing to our own may qualify as references.

Announcement was made through a letter from the Secretary of the Board of Trustees of the gift to the library by John W. Lieb, Jr., of a series of rare volumes covering the work of Leonardo da Vinci. The Secretary was directed to express the sincere appreciation of the Council.

The formation of student branches at the Universities of Michigan and Colorado was approved.

CALVIN W. RICE, *Secretary*

AN INCREASING MEMBERSHIP

The names of applicants for membership published in The Journal from month to month indicate the regular and substantial growth which the Society is experiencing. From January 1 to March 31 the total number of these applications was 524, of which 323 have been received during March alone. In looking through the list of these applications as published in The Journal it will be noted that comparatively few are for promotion, and that in the majority of cases the applicants are men who are holding responsible positions in the engineering field, whose admission will serve to maintain the Society's high standard.

The Committee on Increase of Membership recently made an interesting analysis of the applications received from different sections of the country since December 1, as follows:

Chicago	33	St. Paul	7
Philadelphia	26	Atlanta	7
Boston	24	Seattle	7
St. Louis	22	Worcester	7
Detroit	15	Milwaukee	6
New Haven	12	Rochester	6
Cleveland	12	Troy	4
Buffalo	9	Providence	4
San Francisco	8	Los Angeles	1
Cincinnati	7		

The following analysis of the alumni of technical colleges from whom applications have been received since December 31 is also of interest:

Massachusetts Institute of Technology	35
Stevens Institute of Technology	35
Lehigh University	34
Cornell University	33
University of Michigan	19
Worcester Polytechnic Institute	17
University of Illinois	16
Pratt Institute	13
Yale University	13
Purdue University	12
Swarthmore College	11
Ohio State University	9
University of Missouri	8
Columbia University	8
Pennsylvania State College	7
Harvard University	6
Brooklyn Polytechnic Institute	5
University of Pennsylvania	5

REVIEW SECTION OF THE JOURNAL

The Foreign Review was started in The Journal three years ago to place at the disposal of the membership some of the least accessible of the engineering data contained in the periodicals which are regularly received in the library of the Engineering Societies. This Review has met with marked success. From the many letters received it is known that a large number of firms and individuals are regularly following its pages and it therefore may be of interest to the membership to call attention to certain features of the Review and to indicate the field that it is attempting to cover.

With the advent of the new Journal, the Review was extended to include the proceedings of engineering societies as well as articles in foreign periodicals. There are regularly received in the library more than 700 publications, of which 250 are in foreign languages and 150 are the proceedings of engineering societies. The 250 non-English publications cover writings in eleven different languages.

With such a diversity of material, it is evident that the Review section of The Journal must cover a very broad field, and it will be found that even in a single issue there are a great variety of abstracts, such as, for example, the results of an expensive and painstaking investigation in some government laboratory of Holland or Russia, an Austrian university or a German factory experimental department; a description of a power plant device from a Scandinavian periodical; a mathematical discussion of a thermodynamic problem from the Bohemian language; a paper presented before a technical society in South Africa or Australia; and a discussion before some American or British organization of international repute.

In the preparation of this matter, the effort is made to incorporate enough of the data in the original publication so that the purpose of the reader will be served without his having to refer to the article itself. Sometimes, however, the extent or nature of the article makes this impossible, in which case enough is said to call attention to its contents and to indicate whether it is worth anybody's while to look into it further. If more information is desired the library is ready to prepare a more extended translation for a nominal sum.

In mathematical articles as a rule only the results are given without the derivation of the formulae. Drawings and tables are often reproduced and units of measurement are given with their American equivalents. Wherever possible, reference is made to publications in the English language containing fuller information on the subjects treated.

It is not alone to the member distant from New York that the Review is proving valuable. It is probable that no reader, even though a frequent visitor to the library, could acquire the information through his own efforts which the Review is regularly supplying. It is not simply the ability to translate articles from foreign languages into English; the most difficult work in connection with the Review is to make the selection of material and then to condense perhaps a dozen pages into a single page of intelligible matter with the engineering idioms correctly given. This latter is of particular importance. While there is no lack of technical dictionaries, there is also no end to the idioms which they do not contain, and the Editor of the Engineering Survey is not infrequently consulted by readers in the Engineering Societies Library who, while they may be proficient in certain foreign languages, are unable to interpret this or that technical term "which is not in the dictionaries."

The Review section of The Journal will be extended from time to time as the resources of the Society permit, so that the library will in this way become of increasing usefulness to the membership at large, as well as to those who are able to consult the books on its shelves. By this means and by researches, translations, the answering of technical inquiries and by supplying references upon engineering subjects, in all of which directions much work is now done, the library will become more and more a factor for service in the profession.

BRINGING THE MEMBERS INTO TOUCH WITH THE SOCIETY

The national character of the Society is emphasized by the meetings which are now held with regularity in many cities throughout the country, by the widespread membership of the various committees, several of which have been very active during the past year in promoting the interest of engineering, and by the large percentage of engineering colleges having student branches. It is the aim of the Society to bring together this scattered membership in closer relations by various means.

This spirit of unity has been greatly increased by personal calls made from time to time by officers or members especially delegated to bring words of greeting from the Society to various gatherings and to discuss with the membership the aims of the Society. Since his election to the presidency, Mr. James Hartness has given up a very considerable amount of time to getting into personal touch with the members in different cities as well as with the student membership. To enumerate a few of the many engagements of this sort which he has filled during the past few months, he attended the dinner and meeting of the Buffalo engineers on February 26; on March 4 he made an address at the Joint Engineers Dinner in Boston; and on March 14 and 31 respectively, he attended the Sibley College banquet in Ithaca and the Engineering College Alumni dinner of the University of Vermont. He addressed the students of the latter college on April

17 and on April 29 was the guest of the Providence Association of Mechanical Engineers at their annual dinner. During May he will speak before the Yale Student Branch on May 1, at the meeting of the Chicago Section on May 13, and before the Engineering Society of Pennsylvania on May 16.

The Society has been glad to welcome at its headquarters during the past month several large groups of students visiting New York on tours of inspection. These groups included more than a hundred men from Sheffield Scientific School, over fifty from both the Case School of Applied Science and Pennsylvania State College, and a smaller group from Rensselaer Polytechnic Institute. A small brochure, describing the Engineering Societies Building and its features of interest, with some details of the Society's work, was distributed to all the students who visited the building. It is by such means as these that the Society and its student branches are being brought into touch with one another to their mutual benefit.

THE INDUSTRIAL BUILDING COMMITTEE

Progress in the work of the sub-committee on Industrial Building was reported at a conference of five members of the committee at Boston, Mass., on April 17, where they were entertained by Charles T. Main at the Boston Engineers Club. In line with the program mapped out at the December meeting of the committee, subjects were assigned to the members as follows: Foundations, Charles T. Main; Types of Structures, William Dalton; Fire Protection, Harry A. Burnham; Factory Windows, John De Wolf; Selection of Site, Chas. Day.

While assigning these subjects to individual members, it is the purpose of the committee to handle all papers under its jurisdiction by such coöperative methods amongst its members that the subjects may be treated in a most comprehensive and exhaustive manner. It was decided at this meeting that specific features should be dealt with in the papers rather than general features, as far as possible. The paper on Foundations will be taken up first and the others in the order assigned.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are under twenty-five years of age and therefore qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before June 10, 1914.

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ABEL, JOHN, Treas. & Factory Mgr., Mersereau Metal Bed Co., Jersey City, N. J.

ADAMS, DAN, Head of Steam Engrg. Dept., Lockwood, Greene & Co., Boston, Mass.

ANDERSON, JOHN N., Engr., Otis Elevator Co., New York

BAMFORD, CHARLES J., Ch. Engr., Agasote Millboard Co., Trenton, N. J.

BASCOM, ROLLIN S., Supt., A. J. Smart Mfg. Co., Greenfield, Mass.

BOURNE, PHILLIP P., Ch. Engr., Epping Carpenter Pump Co., Pittsburgh, Pa.

BURHORN, EDWIN, Pres., Edwin Burhorn Co., New York

CROZIER, HERBERT W., San Francisco Office Mgr., Sanderson & Porter, San Francisco, Cal.

CUTTER, LAWRENCE E., Asst. Prof. of Mech. Engrg., Stanford University, Cal.

DIAMOND, GEORGE A., Mgr., Scheid & Co., Nome, Alaska

EASTMAN, SAMUEL G., Chicago Sales Mgr., Pratt & Whitney Co., Chicago, Ill.

FELIX, SAMUEL P., Eastern Sales Mgr., Dravo-Doyle Co., Pittsburgh, Pa.

FLOWERS, DEAN W., Supt., Gas Wks., St. Paul Gas Light Co., St. Paul, Minn.

FRAZAR, EVERETT W., Managing Director, Sale & Frazar, Ltd., Tokyo, Japan

FREER, WM., G., Pwr. Engr., Schenectady Wks., American Locomotive Co., Schenectady, N. Y.

GASTON, NEWTON D., Efficiency Engineer, Adams & Westlake Co., Chicago, Ill.

GIFFORD, ROY W., Treas. & Mgr., Deyo Machinery Engine Co., Binghamton, N. Y.

HALL, QUINCY A., Secy. & Engr. of Tests, Morgan T. Jones Co., Chicago, Ill.

HARGRAVE, HUGH H., Designer with W. J. Rainey, Uniontown, Pa.

HERR, DONALD D., Genl. Supt. of Constr. and Sales Engineer with A. G. McKee, Cleveland, Ohio

IWANAMI, TAKAO, Draftsman, Interborough Rapid Transit Co., and N. Y. Railways Co., New York

JESSOP, FRANCIS W., Wks. Mgr., The Electric Controller & Mfg. Co., Cleveland, Ohio

JUTHE, KRISTIAN A., New England Representative, Firth-Sterling Steel Co., Pittsburgh, Pa.

KAMMERHOFF, H. H. M., Elec. Engr., Edison Storage Battery Co., West Orange, N. J.

KELLY, ODHER G., District Turbine Inspector, General Electric Co., Chicago, Ill.

KIRSCH, JAMES L., Palmerton, Pa.

LANGE, PAUL H., Engr., Niagara Machine & Tool Works, Buffalo, N. Y.

LITTLE, ARTHUR L., Mech. Supt., Eastern Mfg. Co., South Brewer, Me.

MASON, EARL P., Secy. & Supt., Newport Engrg. Works, Newport, R. I.

MAYO, EDWARD D., Ch. Engr., The Barnett & Record Co., Minneapolis, Minn.

MORRISON, W. B., Asst. Genl. Mgr., McIntosh & Seymour Corp., Auburn, N. Y.

NYE, HORATIO V., Asst. Supt., The Northwestern Consolidated Milling Co., Minneapolis, Minn.

OLSON, MARTIN L., Instr. in Mch. Shop Practice and Drawing, Public Schools, Boston, Mass.

PATTERSON, EUGENE C., Secy. & Genl. Mgr., Chattanooga Boiler & Tank Co., Chattanooga, Tenn.

PEDERSEN, NIELS, Genl. Supt., Sloan & Chace Mfg. Co., Newark, N. J.

ROSENZWEIG, SIEGFRIED, Consulting Engineer, York Mfg. Co., York, Pa.

RUTH, CONANT W., Mech. Engr., Stone & Webster Engrg. Corp., Boston, Mass.

SARGENT, WM. F., Representative and Estimator, The Bigelow Co., New Haven, Conn.

SINGLETON, FRED, Mech. Representative, Locomotive Superheater Co., Dunkirk, N. Y.

SMITH, CHARLES H., Engr. & Special Inspector, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

SMITH, EDWIN D., Vice-Pres. & Genl. Mgr., The Arrow Engrg. Co., and Vice-Pres., Amer. Lt. & Pwr. Co., St. Louis, Mo.

STEBBINS, CHARLES B., Ch. Engr., Sheffield Car Co., Three Rivers, Mich.

TENNEY, LEWIS C., Building Engr., Cadillac Motor Car Co., Detroit, Mich.

WADDELL, ROBERT, Ch. Draftsman, Washington Iron Works, Seattle, Wash.

WAGNER, OTTO H., Supt. of Construction, Decarie Incinerator Co., Minneapolis, Minn.

WAGONER, PHILIP D., Pres., General Vehicle Co., Inc., Long Island City, N. Y.

YODER, THOMAS M., Representative, Erie City Iron Works, New York

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BLACK, EDGAR N., 3RD, Asst. Engr., with Wm. H. Timm, Philadelphia, Pa.

BROWN, AUBREY I., Instr., Mech. Engrg. Ohio State University, Columbus, Ohio

CONSOLIVER, EARL L., Field Engr., Hoeschen Mfg. Co., Omaha, Nebr.

FLIPPEN, JOHN P., Testing Engineer, C. H. Wheeler Mfg. Co., North Philadelphia, Pa.

FORD, WINTHROP D., Mech. Engr. & Representative, International Steam Pump Co., Boston, Mass.

FRIED, JEROME A., Research and Consulting Work, 324 Wait Ave., Ithaca, N. Y.

GALLIVAN, JOHN D., Asst. to Genl. Foreman, Hydraulic Dept., Isthmian Canal Commission, Gold Hill, C. Z.

HOSSACK, ARCHIBALD B., Eastern Solicitor, The American Appraisal Co., New York.

KIESELBACH, HENRY A., Mech. Engr., Baker, Smith & Co., New York.

MEIXNER, BERNARD A., Engrg. Representative, R. B. Whitacre & Co., St. Paul, Minn.

SCHOPFER, FRANK H., Designer, E. N. & R. E. Spaulding, Engrg. Contractors, Suffield, Conn.

SHAW, JOSEPH H., Mech. Engr., American Vulcanized Fibre Co., Wilmington, Del.

SMITH, EUGENE, Cincinnati District Mgr., Detroit Stoker Co., Detroit, Mich.

STEE, HORATIO V., Asst. Supt., The Northwestern Consolidated Milling Co., Minneapolis, Minn.

STRONG, ARTHUR P., Asst. Engr. of Ash Handling, Green Engrg. Co., Chicago, Ill.

FOR CONSIDERATION AS JUNIOR

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HAASIS, PAUL W., Special Apprentice, Erie R.R., Huntington, Ind.

HEHEMANN, FRED H., Mech. Draftsman, The Lunkenheimer Co., Cincinnati, Ohio

JONES, LEON B., Asst. Engr., Gas Dept., Pacific Gas & Elec. Co., San Francisco, Cal.

LAWRENCE, MEREDITH F., Representative, The Westinghouse Machine Co., New York

TAYLOR, FORREST C., Engr. & Draftsman, Mechanical Handlor Co., Chicago, Ill.

WALKER, KARL G., Asst. Foreman, Stirling Drum Shop, Babcock & Wilcox Co., Barberton, Ohio

TRANSFER FROM ASSOCIATE

CHAPMAN, DAVID A., Mech. Supt., Wm. Filene Sons Co., Boston, Mass.

FLANDERS, RALPH E., Mgr., Jones & Lamson Mch. Co., Springfield, Vt.

HOGAN, PATRICK H., N. E. Mgr., Dearborn Chemical Co., Boston, Mass.

MITCHELL, GUY K., Prop., Standard Elec. & Elev. Co., Baltimore, Md.

PROMOTION FROM JUNIOR

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HEATON, HERMAN C., Mech. Engr., Sargent & Lundy, Chicago, Ill.

LOVEJOY, FRANK W., Genl. Mgr., Manufacturing Depts., Eastman Kodak Co., Rochester, N. Y.

MOREHEAD, WM. C., First Vice-Pres., Natl. Lt. & Pwr. Co., St. Louis, Mo.

NEELY, FREDERICK L., Mech. Engr., Central Ga. Pwr. Co., Central Ga. Transmission Co., Macon Rwy. & Lt. Co., Ga. Public Service Corp., and Asst. to Mgr., Macon Gas Co., Macon, Ga.

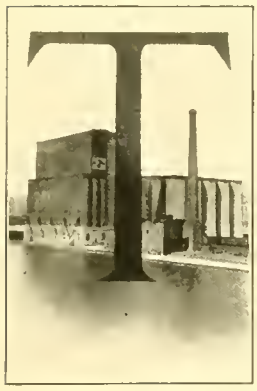
SEWARD, HERBERT L., Instr. in Mech. Engrg., and Supervisor, Power Plants, Sheffield Scientific School, New Haven, Conn.

WILCOX, PERLEY S., Asst. Mgr., Kodak Park Works, Eastman Kodak Co., Rochester, N. Y.

SUMMARY

New applications	69
Transfer from Associate	4
Promotion from Junior	7
	80

ENGINEERING FEATURES OF THE SPRING MEETING



THERE are many points of interest to be visited at the time of the Spring Meeting and the local committee have provided opportunities for the inspection of the great engineering works and industrial developments which have made this section of the Northwest supreme in the production of ore and grain and of the utmost importance in a varied line of industries.

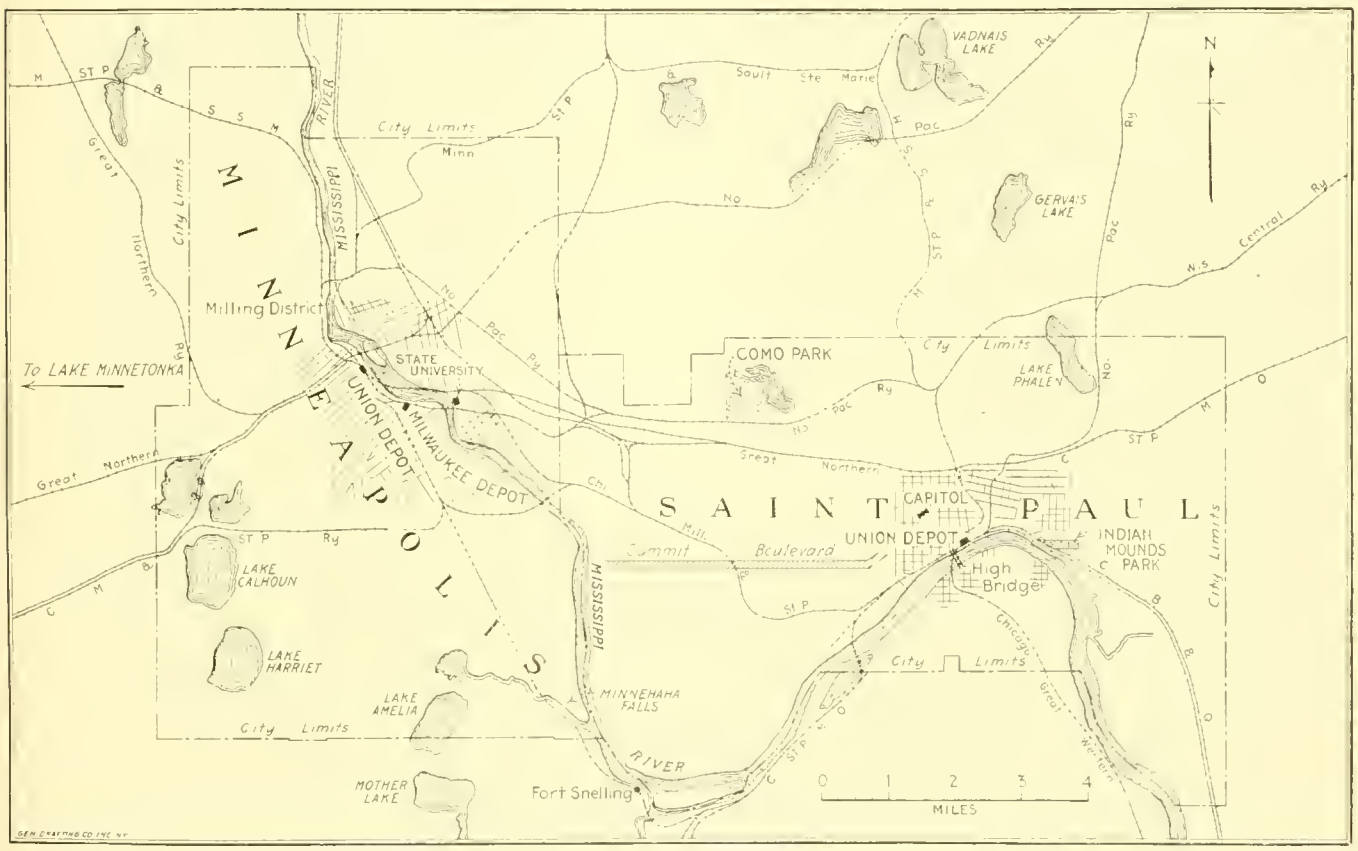
The characteristic feature of the industrial section of Minneapolis is the milling district, the largest milling center of the world, located within a space of eight square blocks. The reason for the concentration of this industry at this point is the immense water power at St. Anthony's Falls on the Mississippi River, which has been supplemented by other hydraulic developments in the vicinity, the latest of which is the High Dam on the Mississippi between St. Paul and Minneapolis, at present almost completed. At the time of the Spring Meeting the 100,000 kw. units of the power station will be in process of installation.

In connection with the mills in the same district are immense grain elevators handling thousands of bushels of grain daily. Representative of this is the plant of the Electric Steel Elevator Company, which has a record of handling 86 cars of grain in 13 hours.

ST. PAUL EXCURSIONS

In regard to the technical excursions, plans have been made for visiting the following points of interest in St. Paul:

The High Dam under construction between St. Paul and Minneapolis, already mentioned. One of the papers of the meeting will be devoted to the subject of this plant.


MINNEAPOLIS
SAINT PAUL
Milling District
STATE UNIVERSITY
UNION DEPOT
MILWAUKEE DEPOT
CAPITOL
UNION DEPOT
High Bridge
INDIAN MOUNDS PARK
COMO PARK
LAKE PHALEN
VADNAIS LAKE
GERVAIS LAKE
LAKE CALHOUN
LAKE HARRIET
LAKE AMELIA
MOTHER LAKE
MINNEHAHA FALLS
Fort Snelling
MISSISSIPPI RIVER
Summit Boulevard
City Limits
To LAKE MINNETONKA
Great Northern
Chicago Great Western
Soo Line
Chicago Milw. St. Paul & Pacific
Northern Pacific
Chicago Milw. St. Paul & Pacific
Minn. Northern
Minn. Sault Ste Marie
Minn. Northern
Minn. Sault Ste Marie
Chicago Milw. St. Paul & Pacific
Chicago Milw. St. Paul & Pacific
Northern Pacific
Chicago Milw. St. Paul & Pacific
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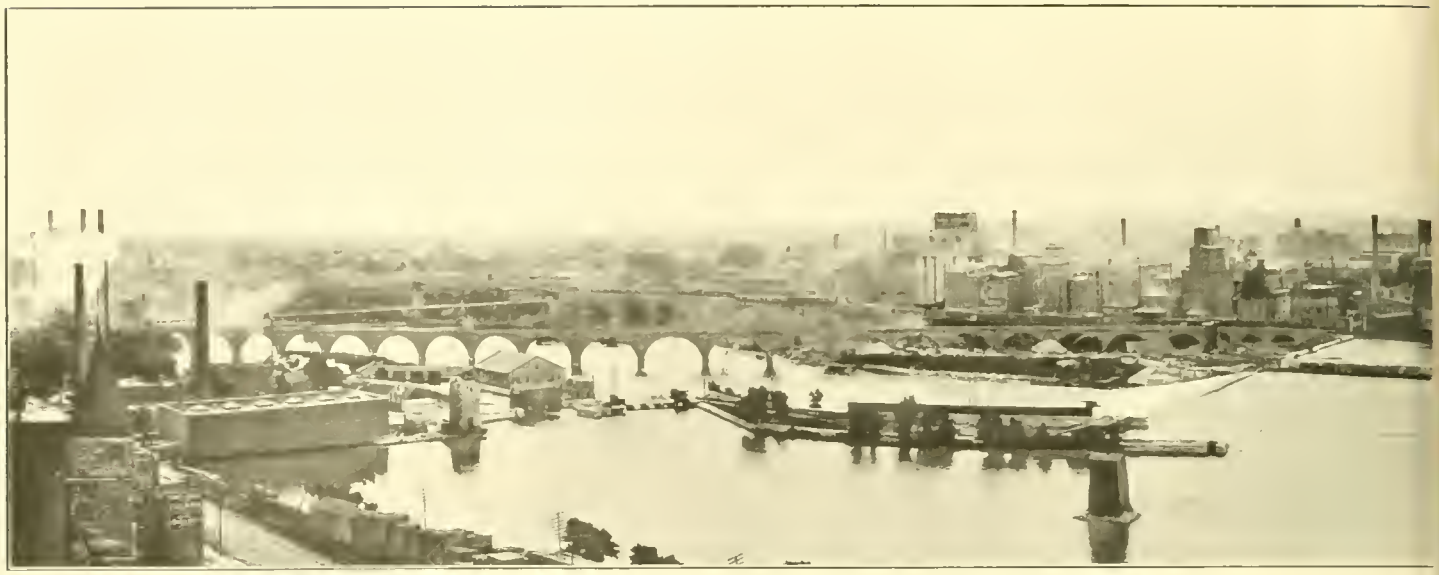
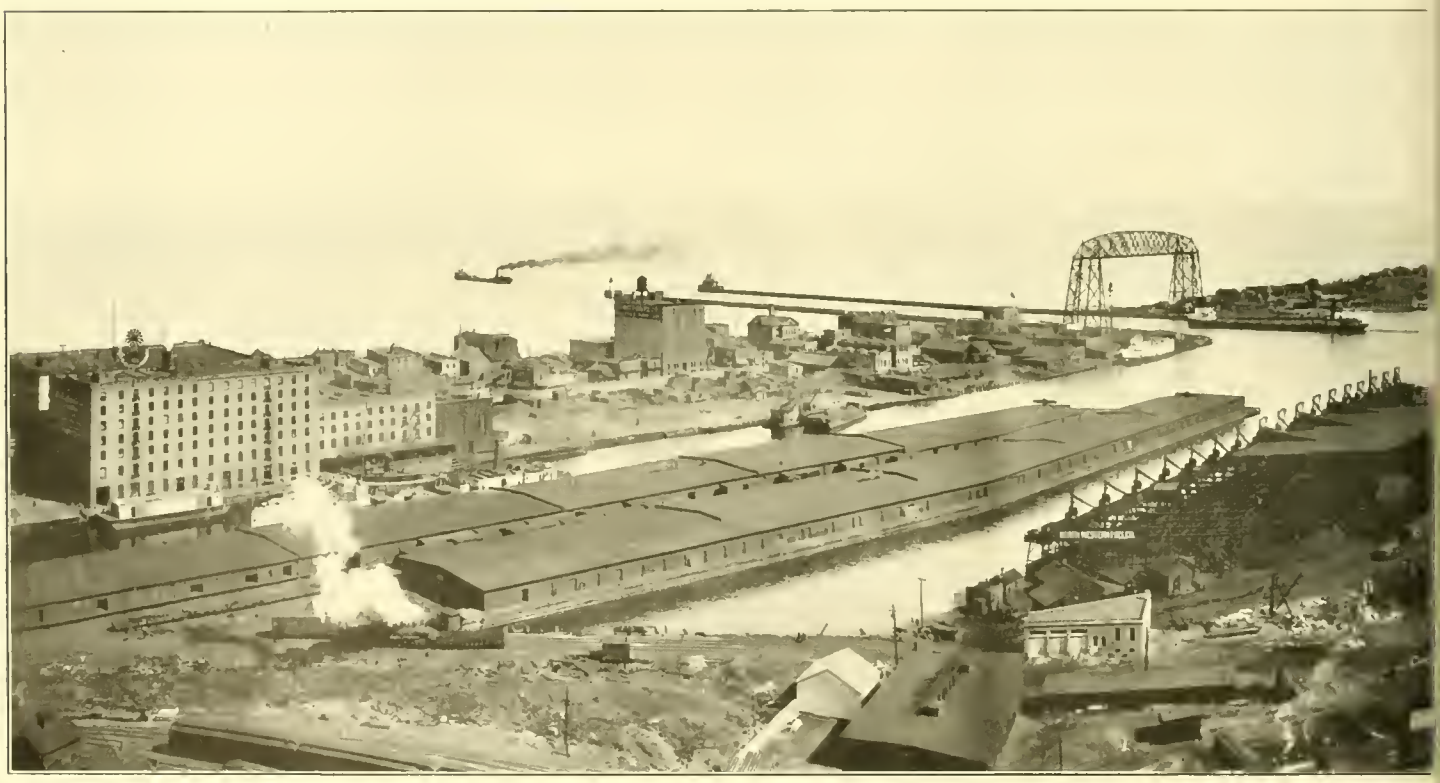


Panoramic View of Minneapolis from East Side of Mississippi showing Milling District, St. Anthony's Falls and Business Section. *The importance of Minneapolis as an industrial center is largely due to water power development: Within the City limits, the Falls of St. Anthony makes available 57,000 horsepower, the Coon Creek Dam furnishes 16,000 horsepower, and the High Dam when completed will furnish an average of 15,000 horsepower; while Taylors Falls on the St. Croix River, a short distance from the City, furnishes 20,000 horsepower, making a total of 108,000 hydroelec-*



Panoramic View of the Harbor of Duluth. *The harbor is naturally landlocked by a strip of land extending from the Minnesota to the Wisconsin shore, a distance of 7 miles. The area of the harbor is 19 square miles and the shore line 49 miles. There are 17 miles of dredged channels from 200 to 600 feet wide. In volume of tonnage the harbor of Duluth is second only to New York in the United States. Last year the total tonnage, mainly of ore, grain and coal, was 46,875,416 tons. Most of the boats enter the harbor through a dredged passage on the Minnesota side. This channel is*

Copyrighted by C. J. Hibbard, Minneapolis

tric horsepower available for industrial purposes in Minneapolis. Near the Falls of St. Anthony within a space of eight square blocks is located the largest milling center in the world. Here are 22 of the 26 mills in operation in this City, among them being the Washburn-Crosby Mills, Pillsbury Flour Mills and the N. W. Consolidated Mills, the total output of whose daily product is in excess of 77,000 barrels of flour. In connection with the mills and in the same district are immense grain elevators handling thousands of bushels of grain daily.

Photograph by McKenzie, Duluth

spanned by the high aerial ferry bridge shown in the view. There are 29 coal unloading docks at the Head of the Lakes with a combined storage capacity of 10,089,000 tons, and a combined unloading capacity of 128,500 tons every ten hours. Almost every type of unloading equipment is represented in the harbor, and the larger docks are electrically equipped. The new ore docks and grain elevators are of steel and concrete construction. Ore and grain are loaded into steamers by gravity and a cargo of 10,000 tons of ore may be loaded in an hour to an hour and a half.

and forge room. The income from the manufacture of twine and farm implements makes the prison self-supporting. The mechanical equipment, plans and specifications for which were prepared by C. L. Pillsbury, consulting engineer for the State Board of Control, include a central power plant, a refrigerating plant, and water supply, sewerage, heating and ventilation, lighting, telephone and telegraph systems and other equipment.

The White Enamel Refrigerator Company, manufacturing house and special refrigerators and the refrigerator equipment for refrigerator cars. There are now about 70,000 of these cars in operation in the United States and Canada and all of the fruit and vegetables raised on the Pacific Coast are transported in them. A second plant of this company, the Northern Insulating Company, is devoted to the manufacture in immense quantities of flax fiber for insulation for refrigerators, the processes of which are unique.

The American Hoist & Derrick Company, manufacturers of derricks of all descriptions, hoisting engines, electric hoists, locomotive cranes, railroad ditchers, log loaders and wire rope clips. The actual working of a railroad ditcher will be exhibited.

Brown & Bigelow, a new plant which is the largest devoted to advertising specialties in the United States, employing 700 people.

The Consumers Power Company, an 8000-kw. power plant.

Griggs, Cooper & Company, a modern and sanitary cracker and candy plant.

The St. Paul Gas Light Company, gas and electric plants.

The St. Paul Bread Company, with modern equipment.

MINNEAPOLIS EXCURSIONS

A number of interesting trips have also been planned to the industries of Minneapolis, among which are the following:

The University of Minnesota, occupying about 120 acres, in a beautiful location overlooking St. Anthony's Falls. The main engineering building, in which the meetings will be held, is a new structure, designed by Cass Gilbert. The University has its own light and power plant which is characterized by the variety of its equipment as well as by its value in developing power economically.

The milling district, including the Washburn-Crosby Mills, the Pillsbury Flour Mill and the Northwestern Consolidated Mills, which have a daily output of 77,000 bbl. of flour.

The linseed mills, the Midland Linseed Products Company and the Archer-Daniels Linseed Oil Company, having a yearly output of 216,000,000 lb. of oil and 432,000,000 lb. of oil cake. This industry is second in Minneapolis only to the production of flour.

The Minneapolis waterworks and filtration plant, having a capacity of 40,000,000 gal., the largest covered basin ever constructed.

The Minneapolis Steel & Machinery Company, making a variety of products from steel bridges to the smallest of iron and steel castings. The tractors made by this concern are a departure in farm implements, designed to replace the horse in routine plowing, harrowing and hauling of farm work.

The Emerson Brantingham Company, manufacturing the Big Four tractor.

The National Mazda Lamp Works, employing 500 persons.

The North Star Woolen Mills and the Northwestern Knitting Company.

The Minneapolis General Electric Company, with their new Coon Rapids water power development and concrete dam.

TRIP TO DULUTH

On Friday afternoon after the close of the official meeting, those who desire to do so will make a trip to Duluth, where there were handled last year 26,000,000 tons of iron ore, 125,000,000 bushels of grain, and 11,000,000 tons of coal. Three-fifths of all the iron ore mined in the United States is furnished by the Minnesota ranges within 100 miles of Duluth. The great open pit mines, in which steam shovels scoop the ore from the earth and load it directly into cars for transportation to the docks, are always of interest to visitors. The towns in the iron range are modern communities with paved streets, parks and fine public buildings. Of particular interest are the new docks and elevators with their equipment for loading ore and grain and unloading coal. These are of steel and concrete construction and the ore and grain are loaded into steamers by gravity. A cargo of 10,000 tons of ore may be loaded within 90 minutes. The most recent coal unloading docks are equipped to handle 1000 tons in 60 minutes and have a storage capacity for 1,000,000 tons each.

For thirty years the ore mined in Northern Minnesota has practically all been carried down the lakes to the furnaces and steel mills, so that the east-bound movement of ore and grain has been much heavier than the west-bound movement of coal. In consequence many boats are forced to run light one way during the season of navigation. What will prove a partial remedy for this is the new plant of the Minnesota Steel Company now nearing completion at Duluth. The initial installation will consist of two blast furnaces, 90 Koppers type by-product coke ovens, ten open-hearth furnaces, with blooming mill, finishing mill, power house, etc. In the vicinity of the city is a 60,000-h.p. hydraulic development on the St. Louis River, and at Coleraine is the interesting concentrating plant with a capacity of 20,000 tons daily, which has increased the economy of marketing the western mesaba ore.

TESTS UPON THE TRANSMISSION OF HEAT IN VACUUM EVAPORATORS

BY E. W. KERR, BATON ROUGE, LA.

Member of the Society

THIS paper deals with a series of tests made at the laboratories of the Louisiana State University to determine the effect of hydrostatic head, density of heating steam, incondensable gases in the heating steam, density of the liquid being boiled, design of the heating compartment, etc., upon the transmission of heat in vacuum evaporators of the kind used in the sugar and other industries.

After making a number of tests on multiple evaporators in sugar factories it was concluded that a special experimental plant would have to be constructed for testing purposes, in order to control the conditions of operation. Accordingly, an apparatus was designed and built in the mechanical laboratory of the Louisiana State University and Audubon Sugar School, and, although considerably smaller than the average commercial machine, was large enough to give results comparable with what might be obtained from units of commercial size.

Five different designs of heating compartments varying as regards tube dimensions, tube arrangement, circulation of juice, steam distribution and manner of removing incondensable gases were tested. As it is very difficult to control conditions in the different bodies of a multiple evaporator, it was decided to use an evaporator with a single body so constructed that the conditions existing in any of the bodies of a multiple evaporator could be reproduced. With this in view the apparatus was so designed that it was possible to change the type of heating compartment and to control at will the pressure of the heating steam, the vacuum under which boiling takes place, the quality of the steam, the amount of air in the heating steam, and the density of the liquid.

The five calandrias tested differ from each other in several fundamental features. Most important among these differences of design may be mentioned proportions of tubes, that is, ratio of length to diameter; the use or non-use of downtakes to aid the circulation of the juice, and the methods employed for removing incondensable gases. What appears to be more or less conclusive data bearing upon the relative merits of these different designs were obtained in the tests. This is probably brought out best in the hydrostatic tests, Fig. 7, also in the temperature level tests, Fig. 8. Both of these sets of curves, however, show the effects of difference of design only in the rough for the reason that the conditions of operation were not the same in all of the tests. In the case of the temperature level tests there was considerable variation in the hy-

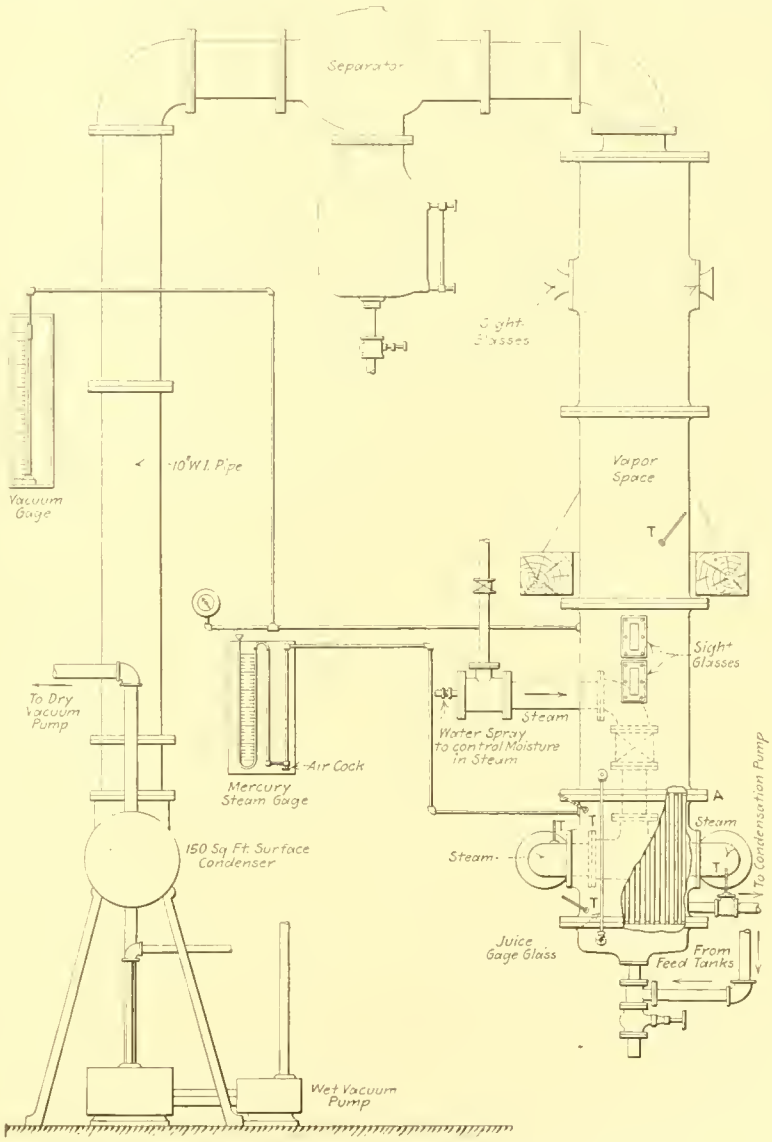


FIG. 1 GENERAL ARRANGEMENT OF EXPERIMENTAL VACUUM EVAPORATOR

Abstract of paper. Published in complete form in the October 1913 issue of The Journal of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Pamphlet copies may be obtained: price, 15 cents to members and 30 cents to non-members.

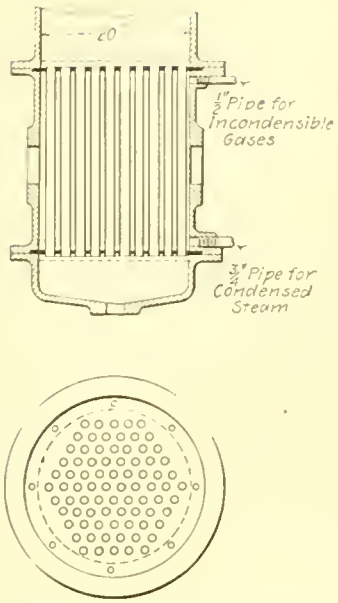


Fig. 2 Calandria A, 80 Copper Tubes 1 3/8 In. by 24 In. by No. 18 B.W.G.

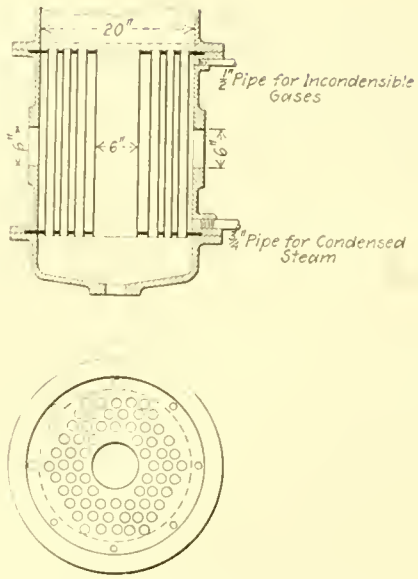


Fig. 3 Calandria B, 66 Copper Tubes 1 3/8 In. by 24 In. by No. 18 B.W.G.; 6 In. Downtake; Tube Plates 3/16 In. Copper

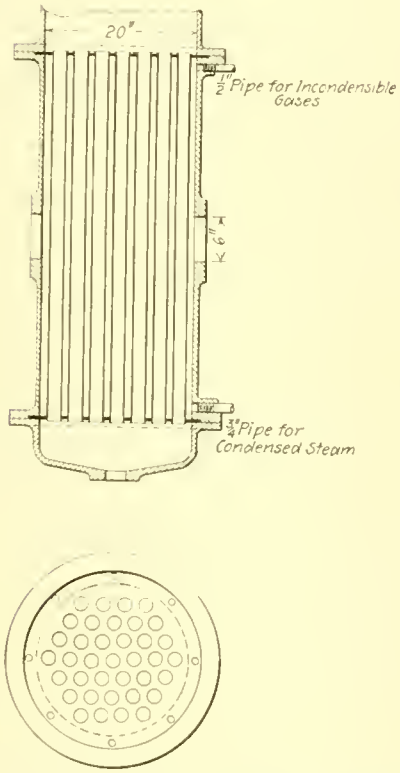


Fig. 4 Calandria C, 37 Copper Tubes 2 In. by 48 In. by No. 18 B.W.G.; Tube Plates 3/16 In. Copper

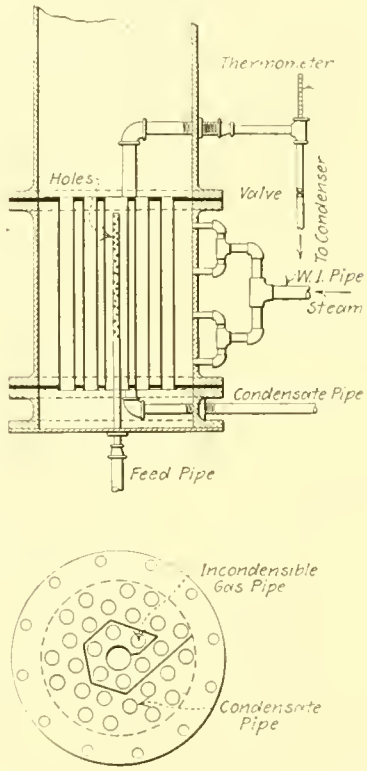


Fig. 5 Calandria E, 30 Copper Heating Tubes 1 3/4 In. by 24 In. by No. 18 B.W.G.; Total Heating Surface 29 Sq. Ft.

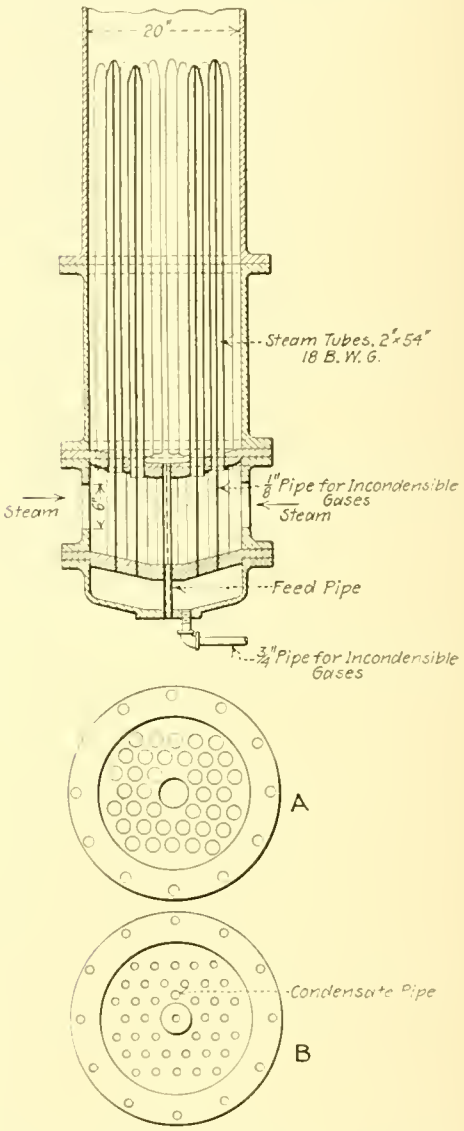


Fig. 6 Calandria D, 38 Copper Heating Tubes 2 In. by 54 In. by No. 18 B.W.G.; Total Heating Surface 86.21 Sq. Ft.

drostatic head. In order to make these tests more nearly comparable the curves of Fig. 8 are reproduced in Fig. 9 with the necessary corrections for hydrostatic head based upon the curves of Fig. 7. The full line curves are taken without change from Fig. 8. The broken line curves are those corrected for hydrostatic head. The principal conditions during the tests are noted on the plat.

Curves 3 and 5 show something as to the effect of varying the proportions of the tubes, the former for tubes 1 3/8 in. by 24 in. and the latter for tubes 2 in. by 48 in., some advantage being shown for the long tubes, at least for low temperature levels. The greater heat transmission in the long tubes is probably due to better circulation. The greater the ratio of the length of a tube to its cross-sectional or carrying area, the greater will be the heat transfer per unit of carrying area and this should increase the velocity of circulation.

A comparison of Curves 3 and 4 shows a decided

advantage for the downtake calandria over that without a downtake. The tests on the downtake calandria were made with a hydrostatic head of 16 in., whereas those on the other were made with a 12-in. head. Correction for this difference would slightly increase the advantage shown for the downtake.

Curves 1 and 6 show the results of the tests on two types of evaporators designed especially for efficient removal of incondensable gases. Both show coefficients of heat transmission considerably in excess of those obtained with the standard types represented by Curves 3, 4 and 5. Curve 6 for calandria E, the baffle plate calandria with a head of 12 in., is only slightly higher than Curve 1 which represents D, the double tube calandria with an 18-in. head. These relations are also corroborated in a general way by the curves of Fig. 7. While the good results shown for these two calandrias may undoubtedly be attributed mainly to the more efficient separation of incondensable gases from steam and their removal, it is probable that the increased velocity of steam is also partly responsible.

CONCLUSIONS

The loss in heat transmission due to hydrostatic head is considerably in excess of the theoretical, and this excess is greater for short tubes than for long tubes. The loss with varying heads, other conditions being equal, varies according to a straight line formula.

Other conditions being equal, the lower the "temperature level" the smaller the coefficient of heat transmission; in other words, the lower the temperature and density of the heating steam the smaller the coefficient. The coefficient of heat transmission varies according to the equation

$$U = 2.25 + 17500\,D$$

where D = density of heating steam in pounds per cubic foot.

Air or other incondensable gases in the heating steam greatly reduce the heat transmission, even with relatively low vacua. The coefficient of heat transmission varies according to the equation

$$C\left(\frac{P_s}{P_t}\right)^3$$

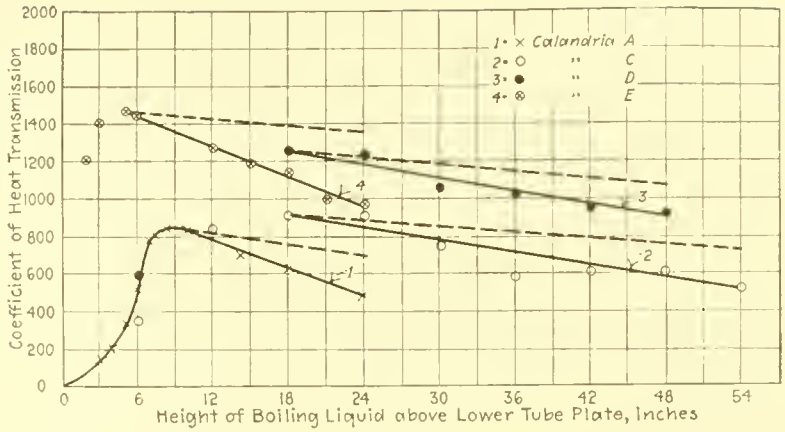


FIG. 7 CURVES SHOWING EFFECT OF HYDROSTATIC HEAD UPON HEAT TRANSMISSION

FULL LINES PLOTTED FROM TEST; BROKEN LINES DRAWN ACCORDING TO CALCULATIONS BASED UPON THEORETICAL LOSS OF TEMPERATURE FALL DUE TO HYDROSTATIC HEAD

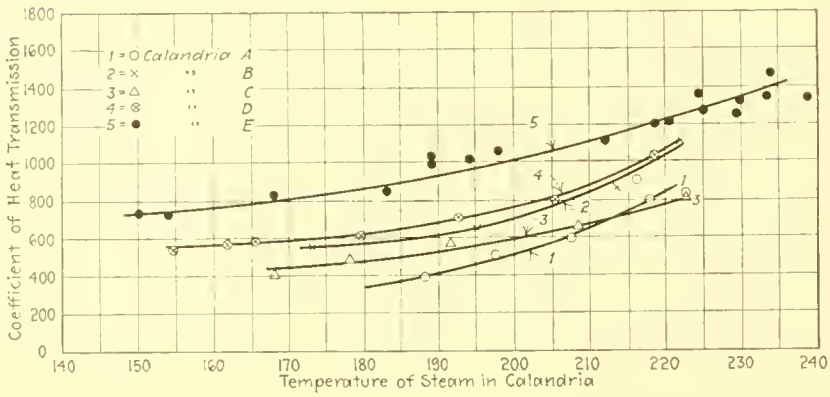


FIG. 8 CURVES SHOWING EFFECT OF TEMPERATURE LEVEL UPON HEAT TRANSMISSION IN FIVE DIFFERENT CALANDRIAS

CURVES PLOTTED FROM TESTS MADE TO DETERMINE THE EFFECT OF VARYING THE TEMPERATURE LEVEL

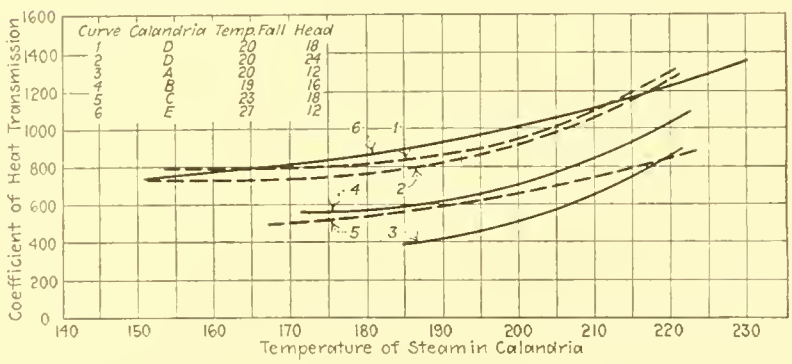


FIG. 9 CURVES COMPARING HEAT TRANSMISSION IN DIFFERENT CALANDRIAS TESTED

FULL LINE CURVES COPIED FROM FIG. 8; BROKEN LINE CURVES SAME AS IN FIG. 8 AFTER CORRECTION FOR HYDROSTATIC HEAD

in which C is a constant, P_s the partial pressure of the steam and P_t the total pressure. The presence of "air pockets" may be conveniently determined by means of thermometers in the steam compartment; good circulation and distribution of steam are important in preventing them.

Increasing the density of the boiling liquid causes a loss in heat transmission due to the decrease in temperature fall. As the density is increased the boiling temperature increases according to the equation $y = CD^{3.1}$, in which C = a constant and D = density in deg. Brix. The total loss due to the density of the boiling liquid seems to be in excess of that due to loss of temperature fall. This is probably due to lower velocity of circulation.

The great temperature fall required in the last body of a multiple evaporator is due to the combined influence of greater amounts of air, steam of lower density, liquid of higher density, also in many cases, more foul heating surfaces, than in preceding bodies.

The downtake or circulation tube was shown to increase heat transmission materially. Long tubes give better results as to heat transmission than short tubes due to better circulation.

The tests show that the double tube and the baffle plate calandrias gave greatly increased heat transmission as compared with the standard types tested, and indicate that attention to steam distribution and the removal of incondensable gases is very important.

DISCUSSION

H. D. Fisher (written). Some years ago the writer had considerable experience with a calandria of the type shown in Fig. 3 of Mr. Kerr's paper. Full details of the apparatus are shown in Fig. 10. It was an experimental apparatus designed for testing out a compression cycle of evaporation, in which the vapor of a boiling liquid was compressed until its saturation temperature was high enough to evaporate a corresponding quantity of the liquid when forced into the steam space of the calandria, at the same time condensing itself. Thus the latent heat of evaporation was never rejected to the condenser as it must be from the last body of a multiple effect, but was used over and over again in the apparatus. A steam coil not shown in the drawing supplied heat lost by radiation and that due to the condensate leaving at a temperature higher than the entering feed though the heat exchange in the lower part of the apparatus returned much of this.

TABLE 1 RESULTS OF TESTS ON FORBES DISTILLING APPARATUS

Test Number	Duration, Hours	Base Pressure Absolute	Compression Pressure Absolute	Temperature of Saturation, Base Pressure	Temperature of Saturation, Compression Pressure	Temperature of Compressor, Discharge	Superheat, Compressor Discharge	Temperature Difference in Calandria	Weight of Water Distilled, lb.	Heat Transfer, B.t.u. per Sq. Ft. per Deg. Difference per Hour	Yield of Water per I.H.P-Hour lb.
1	7.07	32.3	35.1	254.5	259.6	265.5	5.6	5.1	683.0	174	317
2	6.13	32.3	36.6	254.5	261.9	272.9	11.0	7.4	1208.5	245	190
3	3.37	37.5	41.4	263.4	269.4	273.1	3.7	6.0	492.5	222	225
4	3.32	41.6	46.6	269.6	276.6	279.0	2.4	7.0	549.1	214	257
5	4.13	48.0	52.3	278.5	283.9	294.0	10.1	5.4	782.5	316	284
6	3.19	51.0	57.3	282.3	289.7	303.1	13.4	7.4	676.9	258	228
7	3.16	51.9	56.8	283.4	289.2	292.3	3.1	5.8	594.7	291	314
8	3.16	52.2	57.3	283.8	289.7	292.3	2.6	5.9	374.4	181	253
9	3.42	52.4	58.6	284.0	291.2	298.1	6.9	7.2	672.4	245	225
10	3.03	57.0	62.1	289.4	295.0	301.2	6.2	5.6	430.2	227	305
11	2.89	57.0	63.6	289.4	296.5	304.5	8.0	7.1	629.4	274	222
12	3.12	62.1	66.9	295.0	299.9	301.7	1.8	4.9	680.7	395	283
13	3.16	62.2	68.9	295.1	301.9	310.0	8.1	6.8	816.2	339	221
14	3.19	62.8	68.5	295.7	301.5	306.7	5.2	5.8	806.5	388	242
15	3.18	70.8	76.0	303.7	308.5	308.5	0.0	4.8	564.4	327	291
16	3.10	71.3	79.0	304.2	311.2	321.4	10.2	7.0	852.8	349	194
17	3.18	72.1	80.6	305.0	312.6	315.3	2.7	7.6	634.8	232	207
18	3.20	82.1	88.3	313.9	319.0	323.2	4.2	5.1	631.8	340	312
19	3.14	82.3	90.9	314.0	321.0	327.0	6.0	7.0	1024.3	411	264

Steam from the compressor discharge entered through a 2-in. pipe on one side, a little below the middle, and the incondensable gases were vented through a $\frac{1}{8}$-in. pet cock at the top and directly opposite. The apparatus was always run at pressures above atmospheric as thermodynamic theory shows an increased economy at higher base pressures, that is, the pressure in the vapor space, and low compressions. This is strikingly borne out by the results in the last column of Table 1, of yield of condensate per i.h.p. hour of compressor. It was found, however, that at low rates of running there was not sufficient velocity in the entering steam to drive the air out from between the small, closely-spaced tubes and it was only when the apparatus was working at a good rate and with denser steam that satisfactory heat transfers in B.t.u. per square foot of surface per degree temperature difference per hour were obtained.

The heating surface was new at the start of the test and examination at the close showed only a slight muddy deposit on the water side and nothing on the steam side. Water levels were carried about $\frac{1}{4}$ in. above the upper tube sheet in the vapor space and about $\frac{1}{8}$ in. above the lower tube sheet in the steam space.

Compression was apparently practically adiabatic as the

superheats in the steam in the compressor discharge agree quite closely with those calculated from theory, but in all cases the amount of heat represented is negligible compared to the latent heat and it is very doubtful if the superheat has any effect whatever on the rate of transfer.

Mr. Kerr's apparatus is particularly adapted to the elimination of air as he has few large tubes and wide spacings. With commercial designs of calandria even with a steam belt and six or eight contracted openings delivering steam into the tubes at rather high velocities, it is doubtful whether it would be possible to obtain as perfect air venting and as high coefficients of heat transfer as he has done. The ratio of diameter to length of tubes corresponds to the best late practice and should give very satisfactory circulation.

The only criticism the writer has to offer is regarding the length of the tests, as unless steam pressure is very carefully maintained the same at beginning and end, an uncertainty is introduced and with violent ebullition and circulation, it is difficult to be sure a constant water level is maintained inside the apparatus.

A. L. Webre[1] (written). In interpreting the meaning of the results of Prof. Kerr's experiments, several facts must be borne in mind:

(1) The apparatus used was very small as compared with the equipments in practical use today. We know that the relation between a scale model and a full sized unit is problematical. It has been our experience, as a rule, that small vacuum evaporators give much better results than large ones. This is probably due to the more thorough removal of foul gases. It is not practical to obtain a coefficient of transmission greater than 250 in every day work with large units of the types described in the paper as calandrias *A*, *B*, and *C*.

(2) It must also be remembered that the displacement of the condensate pump in his apparatus was many times larger in proportion to the surface in operation than in actual practice. On a 3000 sq. ft. body, it is customary to use a 12 in. single cylinder pump with a piston speed of

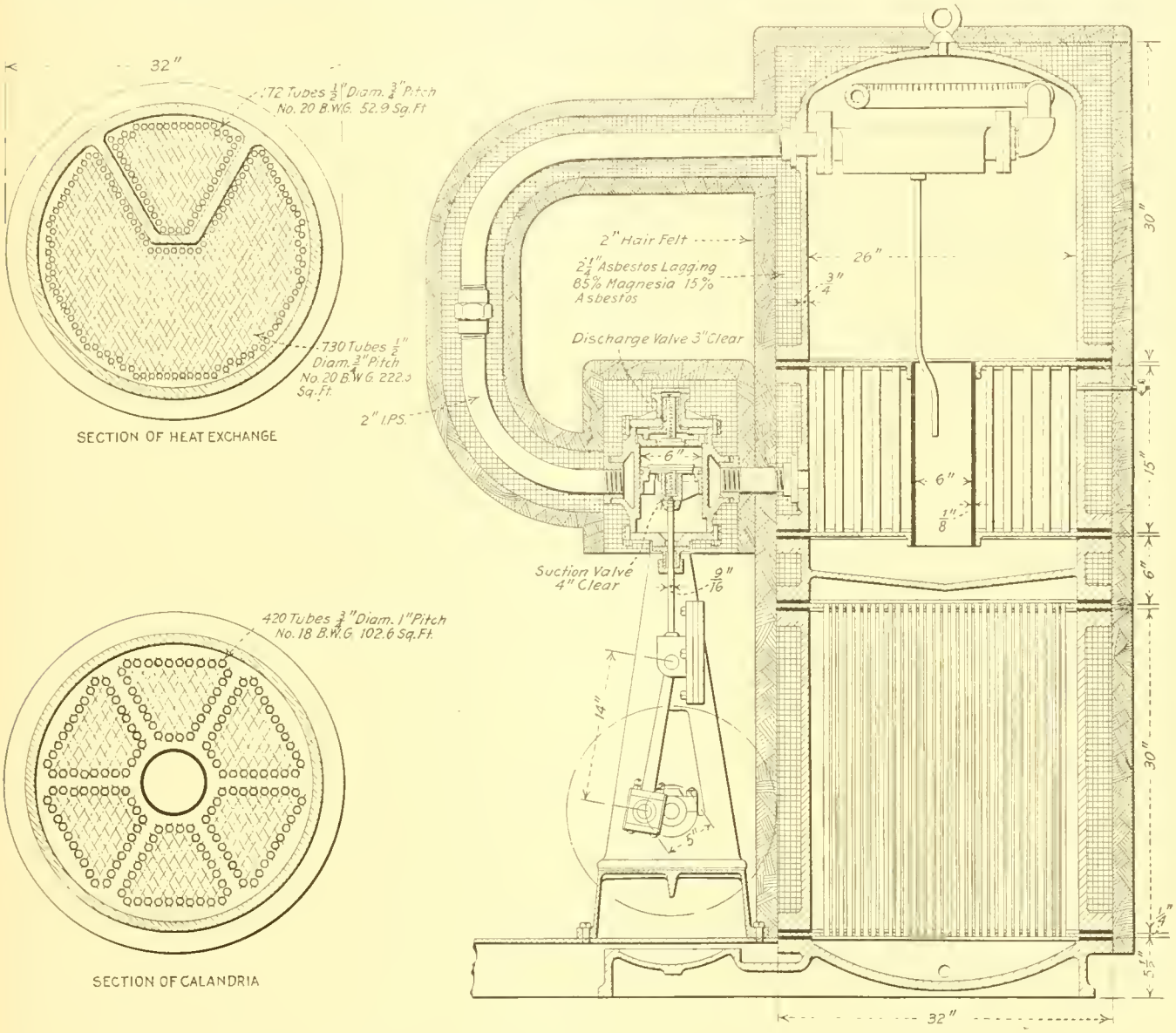


Fig. 10 Experimental Calandria designed for Testing out a Compression Cycle of Evaporation

[1] Mechanical Engineer, John H. Murphy Iron Works, New Orleans, La.

about 50 ft. per minute. Professor Kerr does not give the size nor speed of this pump, but having seen his apparatus personally, we are confident that the displacement was far in excess of that suggested above. This would naturally purge the calandrias more completely of the foul gases, producing very high rates of transmission.

(3) In all the experiments, the temperature of the feed to the evaporator was very low as compared with the boiling point in the apparatus during the tests. It also has been our experience, confirmed by many tests, that far better results are obtainable when the feed enters at or above the boiling point, especially if it is admitted below the tubes. Those of the Society who have had experience in the operation of apparatus of this kind in multiples have, doubtless, noticed that the temperature fall in the first of a triple or quadruple effect is always greater than in the second, in spite of the greater density of the liquor in the second body. This is, doubtless, due to the fact that in the first body, the feed is generally below the boiling point, and in the second considerably above it.

The surface in a multiple effect is designed for evaporating and not for heating. To prove this contention, we have tried to use a single body as a surface condenser with water on the inside of the tubes and steam on the outside, and we secured very poor results. As soon, however, as the liquid begins to boil, there is a remarkable change in the coefficient of transmission. This is due to the slow velocity of circulation when the surface is being used for heating, as compared with the very rapid circulation when it is used for boiling. We understand that it has been established in surface condenser practice that the coefficient of heat transmission is proportional to the square root of the velocity of the condensing water in the tubes. The same law should hold good with evaporator practice.

With slow evaporation, small bubbles of steam cling to the surface actually insulating it from contact with the boiling liquid, and it is only after the circulation is established that these are swept off, so that we can readily understand why higher rates of evaporation give higher coefficients, and long tubes are better than short ones.

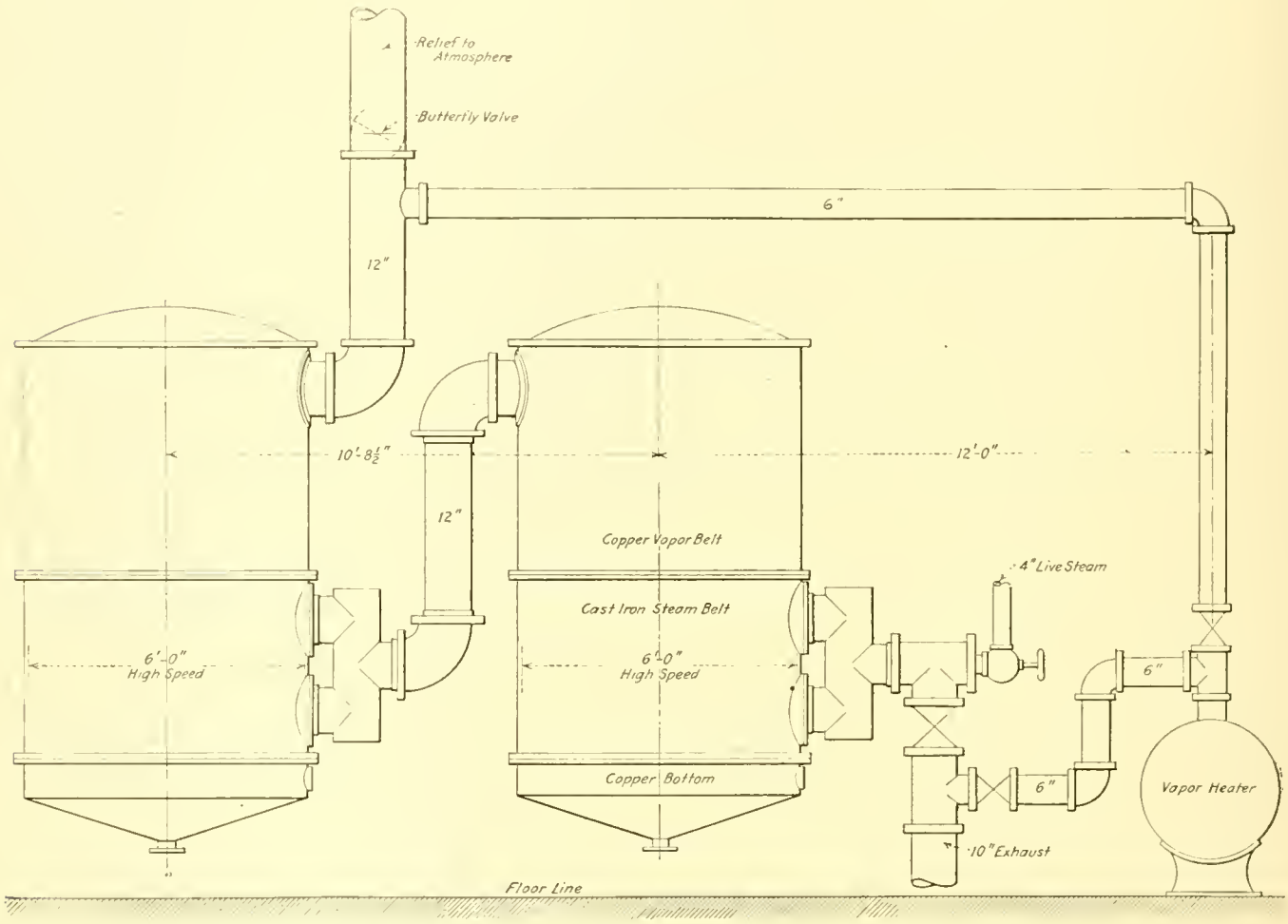


Fig. 11 Design of Atmospheric Double-Effect Evaporator with Vapor Heater

In this connection, we believe that we should be very guarded about coming to conclusions as to the relative merits of calandrias equipped with and without downtakes. This feed temperature problem would naturally affect the calandria without downtake more than the one with a downtake, and might neutralize the apparent advantage shown in Professor Kerr's tests, for it is a fact that there are many effects in Cuba without downtakes giving excellent results, fully as good as those otherwise equipped.

(4) We do not quite agree with Professor Kerr on his comparison of the compromise curves shown in Fig. 9. These curves are made up by altering those shown in Fig. 8. It

will be noted that for both calandrias *D* and *E*, the two temperature level runs were not made with the levels at the points of maximum evaporation, as shown by the juice level series. These points were 18 in. for *D* and 5 in. for *E*. The points selected were 36 in. for *D* and 12 in. for *E*.

Professor Kerr's compromise curves were made by selecting 18 in. as the compromise boiling level. Inasmuch, as on the level series *D* showed a coefficient of 1,257 at 18 in. and 1,025 at 36 in., the curve was boosted up in the ratio of 1257 to 1025, bringing the said coefficient at exactly the maximum point for *D*. This is perfectly satisfactory as far as *D* is concerned. But when the same level is assumed for *E*, and the coefficients are lowered in the ratio of 1256 to 1120, a point nearly 24 per cent below its maximum, we consider that *E* is then at a disadvantage of 24 per cent as compared with *D*.

According to Prof. Kerr, himself, longer tubes give higher coefficients. It is logical to conclude, therefore, that if *E* had had 54-in. tubes as *D* had, it would have shown higher rates of transmission than it actually did show, and with a level of 18 in. would have shown its maximum which would have been above the maximum for 24-in. tubes. It seems to us, therefore, that in order to give *E* an even break levels of maximum evaporation should have been selected if any comparison was to be made at all.

In connection with the high rates of evaporation shown by *E*, which is of our design, we have secured considerably higher coefficients in actual practice. On one of our triples, evaporating 8 lb. per sq. ft. per hour, the drop of temperature in the first body was only 5 deg., and in the second 8 deg. Our ability to boil with a *small drop* has suggested that we operate our effects without vacuum. This we are now doing with remarkable success in atmospheric double-effect evaporators. The capacities are about the same as in the old double effects running under vacuum. Fig. 11 illustrates the arrangement of apparatus for the atmospheric double effect with vapor heater, which has the advantage of doing away with vacuum and water pumps, and the water supply necessary to operate the effects. The pressure in the first calandria is from 6 to 8 lb., which is entirely permissible. The vapors leaving the last body are used for juice heating, which, of course, leaves the largest part uncondensed. It is our intention to use these vapors to operate a vapor vacuum pan.

We want to extend to Professor Kerr our thanks for the painstaking work which he has done, and the valuable information he has worked up. His tests have established facts, which were known only approximately before, and are very useful in that they point the way to scientific design and operation. Experiments, such as he conducted, are impossible on large equipments, and by making proper allowances for this fact, we can interpret their true meaning, and we hope he will incorporate all his data in a good text book, which would be of great service to both manufacturers and operators.

THE AUTHOR. In reply to Mr. Fisher's criticism regarding the short duration of the tests, I will state that the pressure in the heating compartment, also the vacuum in the boiling compartment, was very carefully regulated in all the tests. In fact, they were maintained practically constant throughout each test. Considerable preliminary work was devoted to this matter and the length of the tests was decided upon after it had been shown experimentally that the results were uniform. This is corroborated by the smooth curves shown in the text of the paper. In view of the constant conditions maintained it is believed that the tests were not too short for reasonable accuracy.

The writer agrees in the main with Mr. Webre's observations regarding the fact that the coefficients of heat transmission in the small experimental evaporator used in the tests were greater than are obtained in full sized units; also his reasons therefor, though I will have to take issue with him in some instances. The condensate was removed by a direct-acting 4½ by 6 by 7 in. steam pump, the piston speed being about 40 ft. per min., except in the tests to determine the effect of air where it was varied through wide limits. The displacement of this pump was relatively greater than is generally used in full sized units and this would probably increase the heat transmission somewhat, not only because of a more complete removal of incondensable gases but because of increased steam circulation as well. However, as the speed was kept practically constant for the tests on all the different types of evaporators the results are sufficiently accurate for comparison.

I am inclined to believe that the relatively cool feed would increase rather than decrease the velocity of circulation. Moreover, most of the tests were made with greater rates of evaporation per square foot of heating surface per hour than are usually obtained in practice, which would mean that the velocities of circulation were also greater. In my opinion one of the principal reasons for the high coefficients of heat transmission in the experimental apparatus was the perfectly clean condition of the heating surface, which cannot be maintained in practice even under the most favorable conditions. There seems to be a progressively increasing fouling of evaporator tubes toward the end of the factory grinding season even when they are boiled out regularly with soda and acid.

Mr. Webre's statement that it is not practicable to obtain a coefficient of transmission greater than 250 in everyday work with large units is correct, though it should be remembered that the coefficient is greater in the first body of a multiple evaporator than in the last body and this figure would represent a good average. The writer has lately made some tests upon a large quadruple film evaporator where transmission coefficients for the four bodies were 545, 648, 600 and 207 respectively, the average being 394. The difference between these coefficients and most of those shown in the paper is not excessive.

I agree with Mr. Webre that the compromise curves of Fig. 9 show the relative heat transmission of the different types only approximately. The juice heads 18 in. for calandria D and 12 in. for E were used instead of those of maximum evaporation because it was thought they would be approximately the same as would be used in practice. With the 24-in. tubes of E, it is quite natural that lower heads can be carried than with the 54-in. tubes of D. It is evident that the calandria with tubes 24 in. long has an advantage over those with tubes 48 in. and 54 in. long as regards juice head; also the heads for maximum evaporation would be lower with the 24 in. tubes. I am inclined, therefore, to think that compromise curves corrected to maximum evaporation heads would not furnish a fair basis of comparison for these two types. Tests recently made on full sized evaporators of types D and E seem to indicate that the ratings shown by the compromise curves are not far from correct.

TESTS OF VACUUM CLEANING SYSTEMS

By J. R. McColl, Detroit, Mich.

Member of the Society

The paper gives an outline of some tests of vacuum cleaners made for the Board of Education, Detroit, Mich. The tests were divided into two series: (*a*) with the machines on hose and piping as presented or recommended by the manufacturers; and (*b*) with all machines on the same hose and piping system, for the purpose of direct comparison. Each of these series was divided into two parts: (1) tests for ability to do work at the tool end of the hose; (2) analyses of machines as machines.

The paper outlines some of the fundamental principles of vacuum cleaning and contains various curves and tabulated data giving the results of the tests in detail, covering energy developed, power consumption, losses in hose and piping, efficiency, etc.

The specifications provided that in grading machines the ability to do work should not count for more than two-thirds of the total score. It was the sense of the committee who assisted that a machine which makes a fine showing in ability to do work and yet has a low score as a machine is as much to be avoided as one which gains a high score as a machine and shows a poor ability to do work. The two features must be considered together in rating a machine. After going over various details involved, the consensus of opinion was that for a school building, 60 points should be

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TABLE 1 RESULTS OF TESTS

1	2	3	4	5	6	7	8	9		10	11	12			
Designating Letter	Type of Machine	No. of Sweeper	Size of Piping, In.	Size of Hose, In.	Score	Electric Current Consumption in Kw-Hr. For Column 9	Electric Current Consumption in Kw-Hr. For 80 cf. Fr. Air	Cu. Ft. Free Air for 1 In. Vacuum Inside Orifice		Vacuum at Machine for 80 Cu. Ft. Free Air per Minute per Hose	Displacement at Machine for 80 Cu. Ft. Free Air	Pull to Move Following Lengths of Hose on Floor in Lb. 75 Ft.	37½ Ft.	25 Ft.	12½ Ft.
		As proposed—one-sweeper capacity													
F_1	Rotary Exhauster.....	1	2	1½	93.4	2.72	3.23	86.6	2nd test	7.13	106.0	18 25	8.25	5.5	3.0
D_1	Multi-Stage Fan.....	1	3	1½	93.2	1 85	1.76	90.5		3 75	92 0	22 5	9.5	7.0	3.5
G_1	Single-Stage Fan..	1	3	25′ = 2¼″ + 50′ = 1¾	85.6	1 62	.....	61.5		.....	.....	22.0	7.0	4.5	2.5
F_1	Rotary Exhauster.....	1	2	1¼	84.0	2 15	.....	67 3	1st test	.....	.....	13 0	5.5	4.75	2.5
C_1	Rotary Exhauster.....	1	2	1¼	82.0	2 5	2.5	82.0		76 2	108 5	19 5	9.0	4.75	2.5
		As proposed—two-sweeper capacity													
G_2	Single-Stage Fan.....	1	3	50′ = 2½″ + 25′ = 1¾	97 6	1 95	.95	177.8		2.07	86 0	22 0	7.0	4.5	2.5
F_2	Rotary Exhauster.....	2	2	1½	85.5	3 95	.....	142.0	2nd test	.....	.....	18 25	8.25	5.5	3.0
B_2	Rotary Exhauster.....	2	2	1¼	83 0	9 25	4.22	175 5	2nd test	9 87	121 0				
F_2	Rotary Exhauster.....	2	2	1¼	78 7	3.99	.....	115 3	1st test	.....	.....	13 0	5.5	4.75	2.5
B_2	Rotary Exhauster.....	2	2	1	66 0	10.8	.....	93 8	1st test	.....	.....	23 0	10.75	5.5	4 0
E_2	Reciprocating, Plunger	2	2	1¼	57 7	11.5	5.37	169.0		9.55	118.8	19 5	9 0	4.75	2 5
A_2	Reciprocating, Plunger	2	2	1	35.4	6.7	.....	97.1		.....	.....	25 0	13.5	8.5	5.25
		Comparison on school board hose—one sweeper													
F_1	Rotary Exhauster.....	1	3	1¼	90.3	3 11	3.1	80 8		7 3	107 0				
F_1	Rotary Exhauster.....	1	2	1¼	88 9	3 27	3.0	78 2		.....	.....				
D_1	Multi-Stage Fan.....	1	3	1¼	86 9	1 65	.....	59 0		.....	.....				
C_1	Rotary Exhauster.....	1	3	1¼	80.5	2.45	2.5	78 8		7 25	106.5				
G_1	Single-Stage Fan.....	1	3	1¼	68 7	0.7	.....	28 0		.....	.....				
		Comparison on school board hose—two sweepers													
F_2	Rotary Exhauster.....	2	3	1¼	83 9	4 67	.....	135.0		.....	.....				
B_2	Rotary Exhauster.....	2	2	1¼	83.0	9 25	4.22	175.5		9 87	121 0				
F_2	Rotary Exhauster.....	2	2	1¼	82.0	4.25	.....	128.4		.....	.....				
B_2	Rotary Exhauster.....	2	3	1¼	75.3	3.5	.....	131.0		.....	.....				
G_2	Single-Stage Fan.....	2	3	1¼	72.3	1.45	.....	69 5		.....	.....				
E_2	Reciprocating, Plunger.	2	3	1¼	61.5	12.73	6.5	183.0		10 1	122.5				
E_2	Reciprocating, Plunger.	2	2	1¼	57.7	11.45	5 37	168 6		9 55	118.8				
A_2	Reciprocating, Plunger.	2	3	1¼	48.5	5.4	.....	148 7		.....	.....				
A_2	Reciprocating, Plunger.	2	2	1¼	45.8	5 3	.....	139.0		.....	.....				
		3-in. Piping and proposed hose													
F_1	Rotary Exhauster.....	1	3	1½	95 3	2 58	3 15	90 8		7.1	105 6				
F_2	Rotary Exhauster.....	2	3	1½	86.3	3 82	.....	146.0		.....	.....				
G_1	Single-Stage Fan.....	1	3	25′ = 2¼″ + 50′ = 1¾	85.6	0 78	.....	61 5		.....	.....				
C_1	Rotary Exhauster.....	1	3	1¼	80.5	2.45	2.5	78 8		7.25	106.5				
A_2	Reciprocating, Plunger.	2	3	1	34 4	6.9	.....	94.0		.....	.....				

given to the machine as a machine and 40 points to its ability to do work. This was of course an arbitrary standard, regarding which there would no doubt be a wide diversity of opinion among engineers, but as long as all machines were scored uniformly in accordance with this assumed standard, it has the stamp of fairness. The 60 points for the machine as a machine, were divided as follows:

Maintenance and repairs	20	
Simplicity	5	
Lubrication	5	
Dust collection	5	
Space	5	
Noise	5	
Tools and hose	15	60
Ability to do work		40
		100

The specifications provided that the vacuum cleaning system must be of a capacity to take care of two sweepers operating simultaneously on a given system of piping, each sweeper to be provided with 75 ft. of hose. The capacity requirement for each sweeper was stipulated as 80 cu. ft. of free air to be handled with a vacuum of 1 in. of mercury inside an orifice at the tool or sweeper end of the hose.

DISCUSSION

H. M. Grossman[1] (written). The extreme value of Mr. McColl's paper lies in the fine comparison which the data give of the three different types of vacuum cleaning machines: namely, the reciprocating plunger or piston pump type; the rotary exhauster type; and the high-speed centrifugal fan type of either single or multistage design. The development of the vacuum cleaning industry has been very rapid during the past three or four years, and as the industry grew this development has brought out the three distinct types in the following order:

The Reciprocating Plunger or Piston Pump Type. This machine consisted of an ordinary cylinder with a reciprocating piston working therein, and with the usual intake and exhaust valves. This plunger or piston pump design was admirably adapted to the production of a high vacuum, but the ability to displace air when the various cleaning tools were in operation was very limited. The fact that the piston pump had always been used when it was necessary to produce a vacuum led naturally to the use of the same device in producing the vacuum for the first vacuum cleaners. In the design and construction of the first type of vacuum cleaners the inventors and builders did not recognize the fact that the volume of air in motion was the essential cleaning agent and that the vacuum was only a means for causing this flow of air.

Since the characteristics of this machine were inherently high vacuum with a very low air displacement (or high-vacuum low-volume) it was equipped with a piping and hose system of very small diameter. The cleaning tools were also made of very small size. The result of this small pipe, hose and tool equipment was constant trouble from clogging of the pipe system, together with a general inability of the cleaning tool to pick up anything except the finest dust. These facts, coupled with rapid wear and tear in the elaborate mechanism of the machine itself, led to almost endless trouble, and required the services of a skilled mechanic to keep it in operating condition. The machine also required an elaborate system of separating tanks to separate every particle of dust from the air before drawing it into the cylinder. Even with the greatest of precaution it was frequently necessary to rebore the cylinder after less than a year of use. Naturally, the cost of maintenance of this type of machine was very high. The power required to drive was also very high as compared with the later types.

The Rotary Pump or Rotary Impeller. This type of machine was brought out with the idea of obtaining greater air displacement per sweeper with less vacuum maintained at the machine; also, with the hope of eliminating the trouble experienced in the first type due to excessive wear of the piston and cylinder. The second type of machine did eliminate all reciprocating parts and substituted a true rotary motion in the vacuum producer, which, in itself, was a decided advantage. The vacuum producer consisted of a casing with a series of close fitting blades or impellers revolving therein. In order to maintain the necessary vacuum the clearance between impeller and casing had to be made exceedingly small, which again caused trouble as soon as a small amount of dust or dirt reached the impeller; therefore, this machine required the same elaborate system of dry and wet separating tanks to protect the vacuum producer from excessive wear. This system used pipe, hose and cleaning tools of almost the same size as the first type mentioned, but the power required to drive this machine was much less.

The High-Speed Centrifugal Fan Type. The third and final step in the development of the vacuum cleaner is found in the adoption of the high-speed centrifugal fan, which brings us to the present style of machine, so successful commercially. This type of machine is designed on a new principle entirely, namely, high-volume and low-vacuum. In other words, the vacuum cleaning industry has developed until it recognizes that a large volume of air in motion is required to do rapid and effective cleaning; or, that a comparatively large volume of air in motion is the only cleaning agent, and that the vacuum is nothing more than a means to cause this air to flow.

The machine consists of a high-speed centrifugal fan revolving freely in a snail casing and direct connected to a motor or steam turbine. The volumetric capacity of the fan for displacing air is very large as compared with the first and second types of machines, while the vacuum maintained at the machine is comparatively low. Due to the inherent qualities of a centrifugal fan to displace air, the vacuum maintained at the machine is practically constant regardless of the number of sweepers in operation. The piping system, vacuum hose and cleaning tools are all considerably larger than in the previous types, thus permitting a large volume of air to pass, which, in turn, means a high velocity around the tool lip and a consequent thoroughly effective cleaning of the fabric or floor over which the tool is passed. The separation of the dust and dirt is accomplished by the gravity process, which eliminates all trouble breeding cloth bags and water sprays such as were necessary in the first and second types.

[1] Consulting Electrical Engineer, 817 Bellevue Ave., Canton, Ohio.

The design and construction of the machine itself is so simple and rugged that the only attention required is an occasional oiling of the bearings and the emptying at intervals of the dirt receptacle. Self-aligning ball bearings running in a constant oil bath constitute the only frictional or rubbing parts. This type of machine has decided advantages, such as simplicity of design, low first cost, low cost of maintenance, low power consumption, great durability, and ability to do fast and thorough cleaning.

There is another very important point in connection with all vacuum cleaner installations of the past which has been overlooked or neglected in most cases. This point may be summed up in just four words: Too Much Vacuum Hose. In other words, the practice has been in the past to use a piping system of so few risers and of such limited extent that it was necessary to use from 75 to 100 ft. of hose per sweeper in order to reach all parts of the building. The vacuum hose is the particular part of an installation that receives the greatest wear and tear; at the same time it is the weakest, and the most expensive part of the installation. Therefore, in order to reduce the amount of vacuum hose necessary, the piping system should be more extensive; that is, provided with a greater number of risers and inlets throughout the building than has been the custom in specifications of the past. The engineer, architect, and building manager, when in position to do so, should always specify a piping system that will require the use of no more than 50 ft. of vacuum hose per sweeper. This sort of piping installation will reduce the cost of maintenance to a minimum and also make the cleaning of a building a far easier task. In fact, this item alone will reduce the cost of janitor service (including time and repairs) several cents per rentable foot. Therefore, let us always insist on "more risers and inlets, with shorter lengths of vacuum hose."

Charles R. Thurman (written). Mr. McColl has evidently given the matter much thought and has brought out some interesting points in connection with a subject which is rather vague in the minds of many writers of specifications. One point upon which there is a wide difference of opinion among manufacturers and engineers is the quantity of air required to do good cleaning. The author has selected 80 cu. ft. per min. with 1 in. of mercury suction at the end of the hose. This is a good figure for heavy duty, but it is unnecessarily high for ordinary work. A good normal quantity for work of the grade found in school houses would be between 60 and 70 cu. ft. per min. and for residence work, 50 cu. ft. per min. is ample. In all cases there should be a surplus vacuum of approximately 1 in. of mercury above what is required to overcome friction losses.

The author refers to the lack of uniformity among manufacturers in regard to the size of the tools and hose used: The wide variations are indeed astonishing to one who understands the important part played in a vacuum cleaner installation by the hose losses. The writer knows one manufacturer who sometimes uses $\frac{3}{4}$-in. hose and tools on one of his stationary machines, and another manufacturer who uses $1\frac{3}{4}$-in. hose and tools. The friction losses in the former are nearly 70 times as great as in the latter, for the same flow of air.

It is the policy of the writer to employ the largest hose that will be acceptable to the average user, provided it can be made with sufficient strength to stand the wear and flexibility enough not to be unwieldy. The result of this policy has been the adoption of two standard sizes: $1\frac{1}{2}$ in. for office buildings, school houses, etc., where the work is done by male janitors; and $1\frac{1}{4}$ in. for household work, which is usually done by maids.

Mr. McColl has brought out a very important point in regard to the limiting size of horizontal mains. This is a point which seems to have escaped a great many designers of stationary installations. It is interesting to note that the writer, entirely independent of Mr. McColl, arrived at a value for the minimum permissible velocity in horizontal pipes to prevent settling of the heavier particles of dirt, which was just 10 per cent lower than the figures given in the paper. This is all the more remarkable when the difficulty of determining such a quantity, even approximately, is considered.

Too much care cannot be taken in making specifications for apparatus to be used in the field for determining the performance of machines. For this purpose, the apparatus must be simple, cheap and easily reproduced. The object of such field tests is to ascertain whether the installation meets certain specifications as regards, what Mr. McColl has styled, "ability to do work." The criterion for such test is usually the suction available at the end of the hose, when the desired quantity of air is flowing. The simplest apparatus for this purpose is a tube to be inserted in the end of the hose and equipped at its outer end with a variety of simple thin plate orifices. A pressure hole is provided in the side of this tube at a distance back from the orifice not less than twelve times the diameter of the tube. In practice, the tube is inserted in the end of the hose and the vacuum measured at the pressure hole with each of one or more sizes of orifice called for in the specifications. This method of test presents an easy means of checking up the "ability to do work" and is one that may be easily standardized and calibrated so that the flow of air may be computed from the size of the orifice and the vacuum measured.

If the pressure hole is too close to the orifice, the result will be misleading. The writer has often observed a vacuum just back of the orifice considerably greater than that at the exhauster, even when there was a long piece of hose between. This phenomenon is due to the velocity conversion in the tube after the pressure hole is passed.

The zones suggested by the author for the different grades of work do not indicate mature thought. In all vacuum cleaner work, due consideration must be given to the workman doing the cleaning, and experience shows that vacua of more than 3 in. of mercury maintained in the tool imposes a heavy burden of labor upon the operator, owing to the adhesion of the tool to the surface. In bare floor tools this difficulty is overcome by various schemes for letting in a rush of air, but for carpet cleaning, such a device defeats the end of the vacuum cleaner by admitting a lot of air, which does not pass through the carpet, and serves only to diminish the vacuum and hence the flow through this fabric. A satisfactory cleaner must have ample air displacement to take care of the fluctuations in demand, due to the rapidly changing action of the tool, and for bare floor work, and must be limited in suction to such a value that the operator is not overworked. In the centrifugal fan type of machine this result is obtained automatically, while in the positive displacement type, recourse must be had to by-passes or pop valves.

The curves showing the relation between the wasted energy and available energy at the tool are very clear. The

large percentage of energy absorbed by the piping system and long lengths of hose required by stationary machines make very evident some of the advantages possessed by the portable and so-called truck machines now on the market, in the use of which the piping losses are entirely eliminated and hose losses reduced from 50 per cent to 75 per cent by reducing the length required.

The Author. I fear that Mr. Grossman in his evident enthusiasm for one type of machine has overlooked many good features of the other types, types which are far from obsolete at the present writing. It was the prophecy of one of the committee who assisted us, that the relative standings of the reciprocating, rotary pump, and fan types of vacuum cleaners will ultimately be similar to those of the steam prime movers of the reciprocating, rotary and turbine types. This doubtless will be a long way off, for vacuum cleaners will never have the prominence in engineering and commercial fields that steam engines have had.

The mechanical efficiency of the fan type of vacuum cleaner, working, as it must do, on a fairly low ratio of opening, is much lower, as a machine, than some of the other types, but its greater simplicity is a valuable offset. The low power consumption shown by some of these machines, for a given duty, is a result of large hose and piping rather than high mechanical efficiency of the machine.

The small hose and piping systems used in the earlier vacuum cleaner work, and still used by some manufacturers, required high vacua at the machines, a matter more of necessity than choice, to get practical results in cleaning. There is no reason why these same machines cannot be used, or at least be designed to be used, on a large hose and piping system as "low vacuum—high volume" machines with surprising results in air handled and diminished power consumption. Machine B_2 (Table 1) for example had a displacement nearly double that which it would have needed on the hose and piping system of G_2. The use of the larger hose and piping systems with the fan type of cleaners, particularly the single stage type, is also more a matter of necessity than choice, and some excellent engineering has been done in adapting these machines (capable of only about 2 in. vacuum as a maximum for a practical unit) to rapid sweeping work.

Piping systems are now quite often installed by heating contractors for adaptability to various kinds of vacuum cleaners, with a view that the machine can be purchased and installed later. If the time ever comes when the hose and tools can be purchased from a general supply house by intelligent selection of engineers and clients, according to the maximum size the user will stand for independent of any particular vacuum cleaning machine, then we shall arrive at an era when the true comparative merits of vacuum cleaning machines, as machines, will be found out as fully as electric motors are now known, independent of the feed lines, or as steam engines independent of steam and exhaust lines.

My experience with thin plate orifices, outlined by Mr. Thurman, has not been entirely satisfactory, probably due to varying *vena contracta* effects. It seems to be desirable to get away as much as possible from eddies near the orifice even though the pressure tube connection is through a capillary hole smoothly finished with the inside of the orifice holder. The exact design of orifice and holder must be given if vacuum-orifice or volume-orifice requirements are specified.

A NEW PROCESS OF CLEANING PRODUCER GAS

By H. F. Smith, Lexington, Ohio

Member of the Society

The tar and other mechanical impurities present in raw bituminous producer gas are in an extreme state of subdivision. The number of particles present is so great and the quantity of gas to be handled in commercial plants so large that the problem presents more than ordinary difficulties. The effectiveness of the ordinary types of mechanical gas washers and purifiers leaves much to be desired. The primary object has accordingly been to produce equipment that will be capable of yielding gas of a higher degree of cleanness than obtainable by ordinary methods.

The gas to be cleaned is first cooled sufficiently to condense the tar vapors and the gas and tar are then passed under pressure through a porous diagram of spun glass. This is in the form of ordinary glass wool (which should be distinguished from slag wool), placed between two metal screens. In passing the diaphragm an important change occurs in the physical state of the tar. On the entering side, the tar exists in a large number of minute particles ordinarily known as tar fog. In passing the diaphragm these particles coalesce, so that on the discharge side the tar particles are of relatively large dimensions which cannot be carried along with the gas current and immediately separate out by gravity.

Any desired degree of gas cleanness can be secured, and no water or other washing fluid is required. That the process is not one of filtration is shown by the fact that in filtering the best results are secured when the rate of flow through the filtering medium is slow, whereas in the present process good results can be secured only when the velocity through the diaphragm is very high; and further, there is no deposit in the diaphragm as in filtration.

The apparatus in its present stage of development is shown in Fig. 2. The raw producer gas on leaving the producer is first cooled to a point where the tar vapors are condensed by being passed through a primary cooler or condenser. From this the gas is carried into an ordinary rotary gas pump B which delivers the gas under pressure into the main C; it is then delivered through the diaphragm E and discharged from there into the main F. A sump or separator G is provided in which the tar accumulates.

It appears to be possible to secure almost any desired degree of gas cleanness simply by regulating the pressure maintained across the diaphragm. A difference in pressure of from 2½ to 4 lb. will give a degree of gas cleanness that is ample for any commercial

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requirement. Thirty cubic feet of gas cleaned in this way can be passed through a white filter paper without producing any discoloration.

The exact method by which this tar extractor operates has not been conclusively demonstrated. One theory is that the tar particles are precipitated by being brought into direct collision with the threads or filaments of the porous diaphragm. That this does not constitute a complete explanation of the process, however, is indicated by the fact that the material of which the porous diaphragm is constructed has a marked bearing on the effectiveness of the process, steel wool, for example, being much less effective than the spun glass.

The author believes, as a result of experiment, that friction is in some way concerned in the process. He

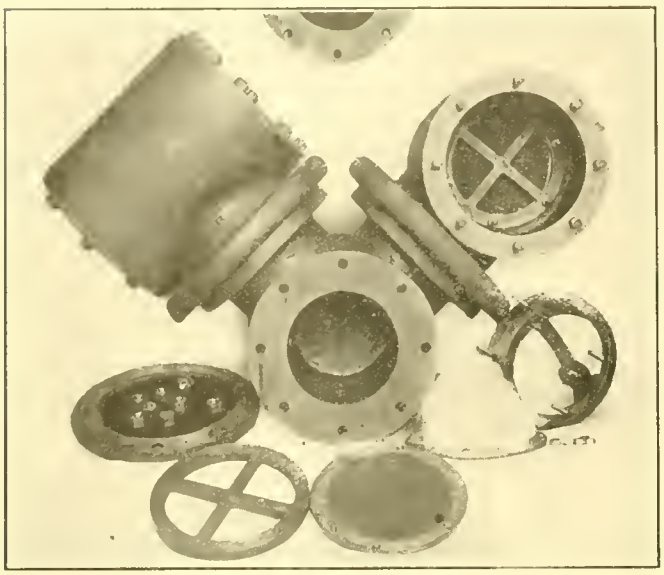

Fig. 1 View showing Various Parts of Commercial Extractor

found that if the gas is caused to pass through a small glass tube with perfectly smooth walls, no particular precipitation of tar occurs as long as the velocities of travel are slow; but that as the velocities increase to a point where there is considerable friction between the gas and the surface of the containing tube, a heavy precipitation of tar occurs on the surface of the glass.

Since friction between rapidly moving gases and containing tubes is known to be productive of electrical phenomena, it was assumed that this might have some bearing on the action. Experiments were conducted with electrodes by which precipitation of the tar particles was effected, and the results were such as to indicate that if the distance between the electrodes could be reduced sufficiently, the differences in potential required for effective electrical action would be very small. He concludes, therefore, that in addition to the effects of mechanical collision there may be a distinct electrical attraction exerted by the glass fibers constituting the porous diaphragm which are located at microscopic distances from each other and which are undoubtedly subjected to some electrification from friction with the gas currents. If the possibility of such electrical action is considered, the increased effectiveness of glass as compared with steel for the construction of the porous diaphragm is satisfactorily explained. That friction of this nature is capable of producing electrical disturbances of considerable magnitude is well established.

DISCUSSION

F. R. Hutton (the chairman) said that the author had brought out an important fact, in establishing that on the discharge side the particles are very much larger and the product is very much less of an emulsion than it is on the upstream side of the porous diaphragm.

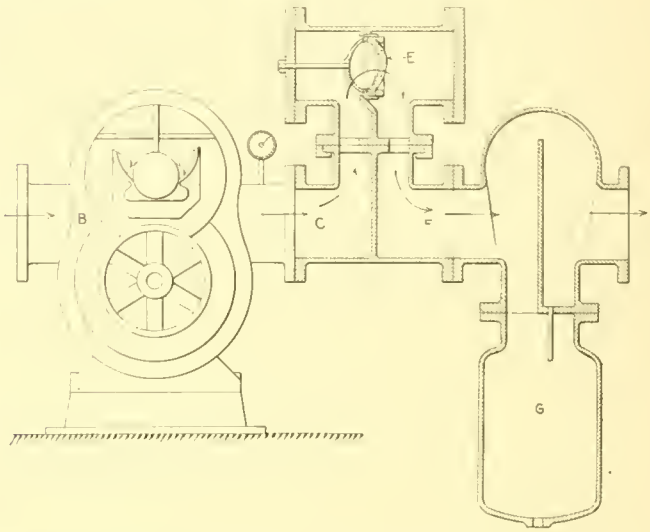

Fig. 2 Details of Static Scrubber and Connections to Blower and Separator

The suggestion of electrical action might also be supplemented by the reference in another paragraph to the fact that at certain velocities there is considerable friction between the gas and the surfaces over which it passes, which causes a heavy precipitation of tar on the surface of the glass. If he had added cohesion of the particles he thought the idea might have been expressed more fully.

Another striking feature of the author's presentation is the significance of spun-glass as compared with any other medium. This means that it is not a filtration, as the particles are not left on the filtering or separating diaphragm. It provides for a cleansing of the diaphragm.

Prof. Wm. T. Magruder suggested as a third alternative the reason for the action of the spun glass is that of a colloidal action, which he did not believe the author had considered. He referred to the wonderful transformations that take place in organic chemistry by colloidal action.

R. H. Fernald. In regard to the power required (in reply to a question by Mr. H. J. K. Freyn) I have no authentic

figures, but the operators at the plants where this particular type of extractor is installed claim that the power required is much less than in the old type centrifugal tar extractor, one operator putting the amount at about 25 or 30 per cent of that required for the old type.

Regarding the claims of cleanliness advanced by Mr. Smith, I cannot make any specific comment other than to say that for some reason the operators find it desirable to change this spun glass at intervals of perhaps three to six weeks. This change is, however, a very simple one and can be made at any time in a few moments and the expense involved is a mere trifle. The frequency of these changes of the spun glass seems to vary with the operator and the interval between changes speedily increases as the operator becomes more familiar with this type of extractor. In one or two of the installations which I recently visited, the operators changed the spun glass at intervals of one or two weeks when the plant was first started. The time was soon extended to three weeks and later to six weeks. Whether the interval will ever be extended to a year is a point that I can not at present answer. In one or two of the plants using this type of extractor, the tar is found to be sufficiently free from water and of such quality as to be of commercial value. In one installation the engineer is credited with $1.20 per bbl. for the tar which he uses in other processes in the plant. It seems to be a tar of real commercial value.

Inquiry of the operators at the plants indicated that the material is comparatively inexpensive, and that comparatively little of the material has to be used, approximately one pound. It was a comparatively inexpensive item, but I do not know where the material is secured.

Some idea of the proportions of this tar extractor may be had if I state that the extractor shown by the author has an overall height of about 5 ft. from the base of the gas main to the top of the upper tee, that is, they are about 30-in. tees. As this plant was operated when I visited it, three of the tees were in series and the fourth was cut out. The tee that was turned at right angles to the main was entirely out of service, and it was then a simple matter to take off the cap and get at the grid containing the spun glass inside. The process of changing the material and cleansing the tar extractor is seen to be very simple.

It may be of additional interest to know that in one installation recently visited which has been operated for several years, considerable difficulty has been experienced from tar in the engines while using the centrifugal tar extractor, according to the statement of the operator. This same operator states that since changing to the new type of extractor outlined in the paper, some two months ago, they have had no trouble from tar in the engine, and they have had a great deal of satisfaction from this extractor.

This question of tar and other impurities from producer-gas in the cylinder of the engine is a very important one. I recently visited a producer-gas installation of 4000 h.p. The same company has another plant which I understand is of the same size, operating on natural gas. The statement of the company is to the effect that the monthly cylinder oil bill is very much more with the producer-gas engine than with the natural gas engine. This brings to our attention some important factors concerning the impurities in producer-gas and the necessity of careful cleansing.

The Author desired to present no closure.—EDITOR.

PRESENT STATUS OF THE LARGE GAS ENGINE IN EUROPE

By Prof. P. Langer, Aachen, Germany

Member of the Society

The tendency to utilize in gas engines the enormous quantities of waste gases from blast furnaces had its inception in Germany about 20 years ago. Large units were created by increasing in size the parts of smaller motors and by using a larger number of cylinders. The two-cycle system also seemed to offer a suitable method of operation for large engines, on account of its more efficient utilization of the mechanism as compared with the single-acting four-cycle system. Full success was not attained, however, until about 11 years ago when the large gas engine was brought to a high state of perfection by the Maschinenfabrik Nuernberg in the form of the double-acting four-cycle type, with two cylinders arranged in tandem.

It was recognized that the principles on which to base the design of large gas engines should involve (*a*) the greatest possible accessibility of all parts exposed to the gases of combustion, and (*b*) relieving the cylinder wall of the weight of the piston. These principles have not only been proved to be correct but their observance has been found to be a necessary condition for the success of large gas engines.

The gas engine puts much higher demands upon the attendant than any other prime mover. It creates its own potential energy by conversion of the chemically latent heat energy of the gas. Almost any defect of the machine, inherent or acquired, which interferes with the conversion of energy, acts destructively upon the machine, not to mention its influence upon the power output. The simple consideration that gas is being burnt without rendering its equivalent in power, leads to the conclusion that the balance is being transmitted to the cooling water under pressures and temperatures beyond what are permissible, and that exhaust gases unallowably hot are flowing around the exhaust valves. In the case of the steam engine a leaky piston does no further damage than to increase the steam consumption. The governor automatically adjusts for a longer cut-off and the engine pulls through as long as the boiler furnishes sufficient steam. With the gas engine, a leaky piston causes ignition at the wrong time which means a release of heat energy at a time and place when this energy can do no useful work. A continuation of the operation under such conditions is not permissible. Any attempt to force the operation would cause heavy damage to the machine.

It is the duty of the designer to face these facts and to design the machine in such a manner that it is pos-

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sible to give it the careful attention needed to prevent such disturbances. Such attention cannot be given when access to such vital parts as pistons, stuffing box packings and valves cannot be had without a long and difficult job of disassembling. The author knows of an engine which, after six years of continuous day and night operation, showed only 0.015 in. wear in the diameter of the cylinder. This success, although immediately traceable to the careful attention this machine received, is nevertheless indirectly due to the designer who made it possible to give such attention through the excellence of his design.

An instance of defective design in this respect is the case of a stuffing box in which it is possible to replace

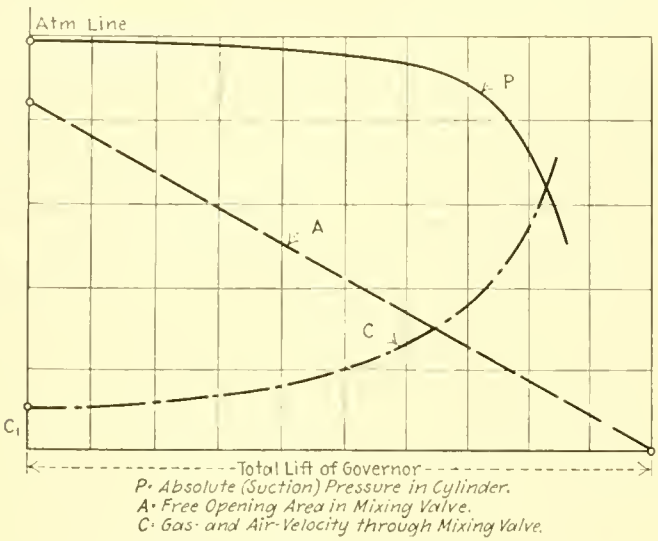

Fig. 1 Curve showing Relations of Opening of Mixing Valve, under Control of Governor, to Suction in Cylinder and Velocity through Valve

the packing rings only by unscrewing the joint between the piston rod and crosshead. The packing rings must needs be split and the whole packing must be easily removable in order that a new packing may be put in during a brief interruption of the operation. The result of neglecting this seemingly minor point of design is a continuation of operation with leaky packings and danger of warping the piston rods.

A further basic condition for uninterrupted operation is pure materials, pure gas and pure cooling water. Degrees of purity of 0.01 grains of dust in 1 cu. m. of gas and of 0.01 grains of dust in 1 liter of water must be attained by cleaning apparatus.

Operation with impure materials puts demands upon the operator which are impossible to meet, except by considerable reduction of the output on account of the long interruptions required for cleaning. It is evident that the economy of the plant suffers materially through reduction of the output, as the proportion of the unproductive capital, the idle machinery, increases. In comparison, the cost of good purifying apparatus for gas and water is of no consequence.

REGULATION OF LARGE GAS ENGINES

The attempt to attain stratification of the mixture inside of the cylinder has led to very complicated valve gears. It was hoped that a gas valve, which remained open during only a part of the suction stroke would direct the gas in such a manner that a combustible mixture would be present at the point of ignition even under the lightest loads, while the balance of the combustion space would be filled with inert air. The result, however, did not justify this hope. Instead of stratification there was only a bad mixture resulting in irregular and uneven operation. Today the hope of attaining stratification can be considered as being finally disposed of and designers have returned to the simple throttling valve gear.

Throttling of gas and air simultaneously, or in other words, regulation of the quantity of mixture only, is to be preferred to the throttling of gas only, as the former method is less sensitive and makes possible a more certain control of the power developed by the governor.

But even the simplest method of quantity regulation

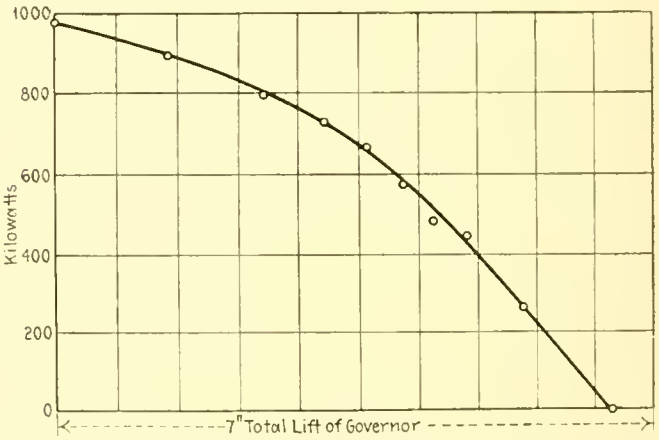

Fig. 2 Curve showing Effect of Proper Adjustment of Governor Mechanism to Obtain Uniform Utilization of Total Lift of Valve

will give satisfaction only if the action of the governor upon the throttle valve has been given careful consideration. Present and older designs that are faulty in this respect are frequently seen. It is wrong to let the governor act in such a way that the valve opening is proportional to the travel of the governor sleeve, as the following consideration will show:

The result of throttling is to reduce the quantity of mixture drawn into the cylinder during each stroke, on account of the reduced openings for gas and air. The volume of the charge remains the same, as the cylinder is always completely filled. The density of the charge will become less and correspondingly its weight and the amount of energy supplied.

These relations are shown in the curves of Fig. 1. Starting with a certain velocity C of the mixture in the valve, which is determined by the opening of the

valve, the curve shows the velocity as a function of the position of the governor. This velocity can be produced only by a certain drop in pressure as the mixture passes to the cylinder, so that the law according to which the absolute pressure in the cylinder changes is also definitely determined.

The density of the charge is proportional to the absolute pressure and the absolute weight of the charge of constant volume is proportional to the density, and so is the amount of heat energy supplied. The shape of this curve shows that the lower part of the travel of the governor sleeve is almost without influence and that the total regulation is limited to the upper travel.

The result of this wrong regulation is marked irregularity of the indicator diagrams, as the smallest motion of the governor causes considerable changes in the quantity of mixture supplied. Combustion is irregular, there is tendency to backfire, or in a word, the machine "does not govern."

The remedy is found in changing the connection between the governor sleeve and the throttling mechanism in a manner such that in the low positions of the governor the throttling action is more intensive than in the upper positions. This action can be accomplished in a simple manner by offsetting the connecting link between the governor and the throttling valve, similar to the arrangement found in Corliss valve gears. This allows a uniform utilization of the total lift of the governor, and consequently stable and quiet regulation, without any complication whatever. Fig. 2 shows a diagram, characterizing the regulation as taken from an engine having a properly designed throttling gear.

Even the best considered scheme of regulation will not avail, if the proportion of mixture, that is, the ratio of gas drawn in to air drawn in, is not properly controlled. In engines that have separate pumps for air and gas, as usual in two-cycle machines, where therefore, air and gas are furnished in measured quantities, it is a comparatively easy matter to get the proper proportion, at least at full load. Difficulties are found, however, in four-cycle machines, where gas and air are drawn in by the working piston in parallel. In this case the proportion of mixture is not readily controlled, because the quantities drawn in depend not only on the free opening of the admission valve, but on the product of this opening area and the velocity of flow through it. Incidental changes in pressure, due to static or dynamic causes, may influence this velocity strongly.

For a long time great difficulties were presented by the problem of driving variable speed blowing engines by four-cycle gas engines. In most cases the gas arrives at the mixing valve under a pressure of several inches of water above the atmosphere, while the pressure of the air is somewhat less than atmospheric. When the machine is run slower the suction action of the piston is reduced and the intake velocity of the air decreases more rapidly than that of the gas, until finally it is reduced to such an extent that nothing but gas enters the cylinder. It is self-evident that, even before this point is reached, the engine will choke with gas and will stop. A governor which regulates the quality of the mixture would only favor this suffocation of the engine with gas. In such cases, too, the conditions are improved by intensive throttling at normal speed.

CYLINDERS

Improvements of design as well as improvements in foundry practice have reduced the breakage of cylinders to a point where it is now rather a rare occurrence. Views upon the most suitable shape still differ, however, considerably. While in all other details of large gas engines standard designs have been developed, which serve all purposes, the cylinder designs still vary considerably. The fact that some designers, after careful experiments, have abandoned the split jacket cylinder in favor of the normal one-piece cylin-

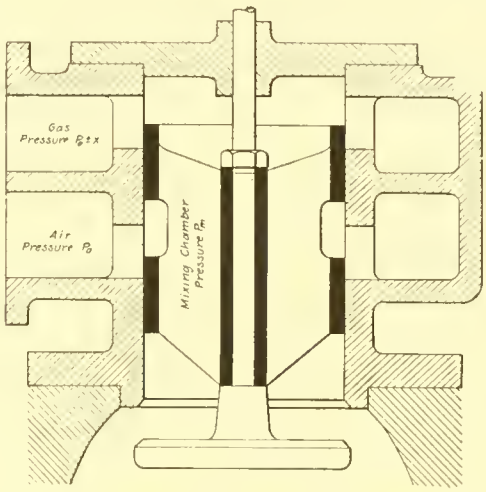

Fig. 3 Typical Design of Mixing Valve for Large Gas Engines

der, while others, also after careful experiments, have gone in exactly the opposite direction, and split not only the jacket, but also the inside cylinder, Fig. 4, seems to show an uncertainty in judging the causes of breakage. These differences in design, however, are caused largely by fixed ideas of the purchasers whose special wishes are complied with by clever salesmen. The one-piece cylinder is just as strong as the split one. The split cylinder has come principally from the desire to avoid initial stresses in the direction of its axis, which put the inner cylinder under tension on account of the fact that in casting it cools later than the rest of the casting. Besides, by casting the two halves separately, it was attempted to obtain as dense as possible a wall for the combustion chamber. Finally, splitting the cylinder has the advantage that customers who consider a cylinder liner the proper construction can be satisfied, inasmuch as the insertion of liners in

one-piece cylinders presents some difficulties, though these are not to be considered insurmountable.

Besides the advantage of simplicity and the absence of the danger of leakage in the highly strained cylinder joint, the one-piece cylinder allows a better transmission of the forces from the cylinder to the frame. The fact that one-piece cylinders frequently broke at the place indicated in Fig. 5, caused an over-estimation of the stresses in the casting. Closer investigation shows that the breaks are caused simply by making the part between cylinder and flange too weak. The wall, besides being too weak originally, is further weakened by the large number of cover studs and the break is further induced by excessive tightening of these studs. This fault can be remedied by properly reinforcing the point of danger and by placing the joint shoulder on the outside. As a matter of fact, breakage on account of strains in the casting or from expansion due to heat, has not occurred in cylinders that were properly reinforced. Improvements in foundry practice have undoubtedly helped to avoid such breakage.

While the breaks just discussed have their origin in the strains set up by irregular cooling of the casting or by irregular heating in operation, cracks of an entirely different nature have been observed on the walls of the combustion chamber. These so-called fire cracks always start in a place where the transmission of heat to the cooling water was impeded from some cause or other (see Fig. 6). The cause of these cracks is to be found in the stresses produced by unequal temperatures within the same wall. In the smooth and homogenous wall the differences in temperature of the different strata are small and the temperature of the wall is comparatively low, as long as accumulated scale or similar causes do not offer an obstacle to the transmission of heat. When, however, the capacity of the wall for conducting heat, or the rate of transmitting heat to the cooling water is reduced, there will be accumulation of heat which will cause a considerable rise of temperature during the expansion and exhaust strokes. The material will tend to expand according to the average temperature of the wall and it will be able to do this without resistance because it was under tension on account of the strain in the casting. In operation, therefore, the strain will be relieved. On account of temperature differences, however, in different strata of the wall, there will be stresses in the wall itself, compression in the hotter zones and tension in the cooler ones.

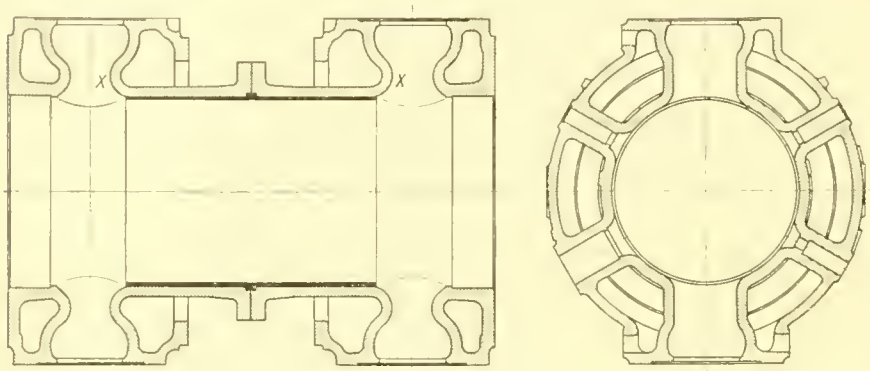

Fig. 4 Design of Split-Jacket Gas Engine Cylinder with Split Inside Cylinder

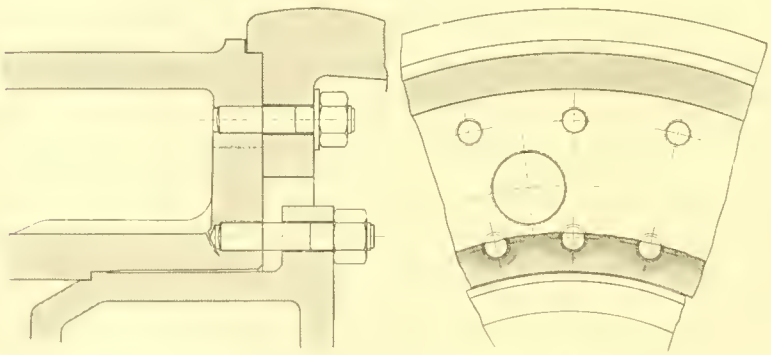

Fig. 5 Detail of Point of Frequent Breakage of One Piece Gas Engine Cylinders

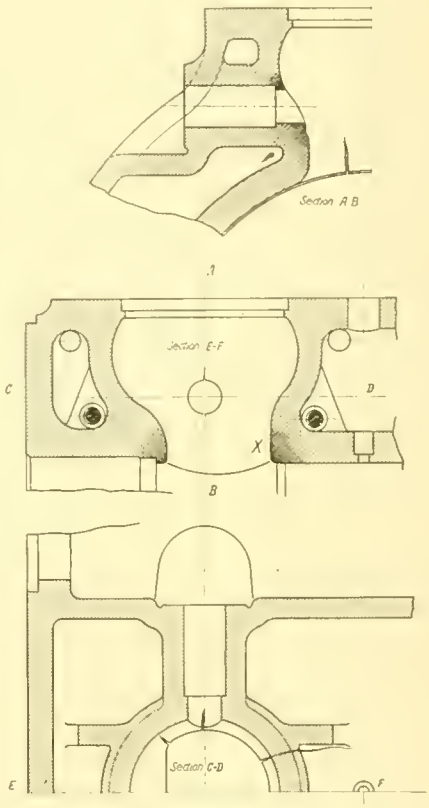

Fig. 6 Typical Locations of Fire Cracks in Places where Cooling is Impeded

This condition of stress can be compared with that existing in a bar being bent towards the inside of the cylinder. In the hotter layer the expansion being resisted causes compression stresses, and in the colder layers there will be tension stresses. As soon as cold mixture is admitted during the next suction stroke, the surface of the wall is cooled intensively. The inside layer of the wall cannot follow rapidly enough to cause the establishment of settled conditions corre-

sponding to this flow of heat. The mean temperature of the wall, and consequently its average expansion can only be affected very slightly during the first moment of internal cooling by the entering cold mixture. The innermost layer will be under strong tension on account of the sudden cooling. This "jumping" of the temperature acts upon the material in much the same manner as sudden flexure from the inside to the outside would. The inside layer of the wall of the combustion chamber, therefore, is exposed to the same kind of stresses as the outside fibre of a bar that is continuously bent in both directions by blows. The stresses which occur under these conditions are about proportional to the difference in temperature, the coefficient of heat expansion, and the modulus of elasticity, if, indeed, one can speak of such in the case of cast iron.

This is an extraordinarily unfavorable case of strain. Cases of strain on account of sudden changes of temperature are not rare, but these conditions are worst in the cylinders of gas engines, on account of the rapid succession of the changes in temperature. A mathematical deduction of these stresses is out of the question on account of the impossibility of obtaining even halfway accurate data on the distribution of temperature at any one moment over the different zones of the wall.

If we bear in mind, however, that a difference in temperature of 200 deg. fahr., when the expansion is restrained, corresponds to a strain of about 15,000 lb. per sq. in., we are surprised to find that cracks do not occur more often. The occurrence of a crack, which in the beginning is scarcely 1/8 in. deep, apparently relieves the strain to a certain extent and only the natural tendency of the cast material to continue to break together with the external mechanical forces causes the crack to open further. In most cases drilling and calking at the end of the crack will stop this. The timely discovery of the crack is, however, rather difficult, as it is not open after the wall is uniformly cooled.

The first step in combatting the occurrence of these cracks must reduce their real source, i. e., the differences in temperature, to an amount that is harmless. As the sudden changes of temperature are caused by the very nature of the gas engine cycle, these attempts must be confined to avoiding all irregular ignition and slow combustion, both of which increase the temperature of the cycle beyond the normal as well as the difference in temperature when the sudden change occurs at the beginning of the suction stroke. Furthermore, it is necessary to make the conductivity of the wall uniform in order to avoid accumulations of heat in the material. It is therefore necessary to avoid all accumulations of material. Passages as shown at X, Figs. 4 and 6, are also bad. Here accumulations of heat are the natural consequence of the imperfect conduction of heat being directed towards a center, the passage at the same time being very much exposed to the cooling action of the incoming air. Places like these are predestined to suffer from heat cracks.

The commonly used globe or onion-shaped passages for inlet and exhaust valves are therefore not suitable, and lately the form shown in Fig. 7 is very properly preferred. Here the valves are brought close to the inner surface of the cylinder.

In a much more effective manner than by measures of design, can the heat cracks, and in fact all cracks that occur in gas engine cylinders, be avoided by proper choice of a material, the constant of which (coefficient of heat expansion multiplied by modulus of elasticity) is less with the same tensile strength than in the case of cast iron. The less the expansion from heat, which is the real cause of the strain, and the more elastic the material, the less the strain.

Considering the enormous progress which metallurgical science has recorded during the past few years, a solution of this question of material should appear possible, and the more so, as nickel steel alloys

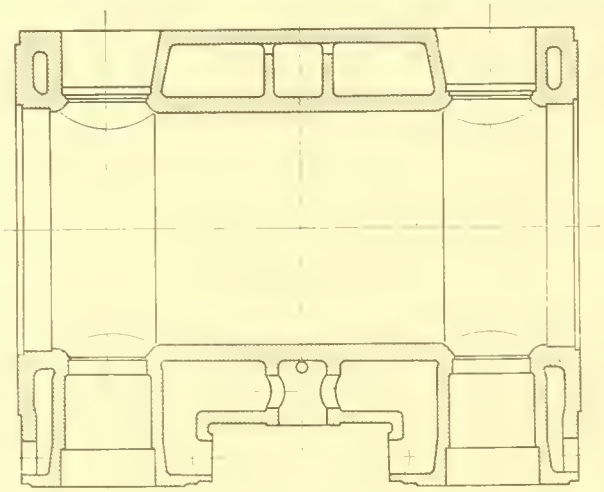

Fig. 7 Recent Design of One-Piece Gas Engine Cylinder that Avoids Globe-Shaped Passages to Valves

have actually been made for accurate rules, in which expansion from heat cannot be detected at all.

An investigation of the constants in question (coefficient of heat expansion multiplied by modulus of elasticity) upon which depends, according to the foregoing, the strain of the material resulting from uneven temperature, shows that cast steel is not a suitable material for gas engine cylinders. The larger expansion due to heat as compared with cast-iron and the very much higher modulus of elasticity causes increased stresses, while the strength of cast steel is not proportionately greater. Experience confirms this conclusion.

ON INCREASING THE OUTPUT OF LARGE GAS ENGINES

The principal task upon which the gas engineer is laboring incessantly, besides that of enhancing the reliability of the machine, is that of making it cheaper, partly by simplifying its construction, partly by increasing its output. At present it can hardly be imag-

ined that the gas engine can be made cheaper by making its construction simpler, now that the complicated valve gears have disappeared. Reduction of weight is not to be recommended. Until recently experience has demanded a continuous increase of engine weights. Economy in material would reduce reliability and length of life of the machine. The mechanism has been developed into standard designs, so that in this detail there is nothing to be saved.

Somewhat better prospects seem to be opened by the attempt to reduce the cost by increasing the output of the machine of a given size. Let us consider the equation for the power of the machine.

$$W = \frac{1}{A} H V \gamma a \eta_v \eta_t$$

in which

V = the swept volume (the factor which determines the absolute cost)

H = the heating value of the mixture

η_v = the volumetric efficiency

η_t = the total efficiency

γ = the number of suction strokes per second

A = the mechanical equivalent of heat

An increase of γ by increasing the number of revolutions per minute, is not practicable, at least not with less combustible gases such as blast furnace gases. The reliability of the machines would be lessened, not even considering the fact that the time available for the combustion of the mixture is too short and that therefore the losses on account of incomplete combustion would become too large. A comparison of the results of operation of gas operated blowing engines, which run relatively slow, and engines driving dynamos, proves that the former require considerably less repairs than the latter. Increasing the number of revolutions would increase the idle time on account of repairs, and a gain in output can hardly be expected.

The heating value of the mixture. H is also determined by the minimum excess of air necessary for complete combustion, and there remain only the two factors of volumetric and total efficiency. It is conceivable that the total efficiency might be increased by increasing the thermal efficiency of the process. This, however, is dependent upon increase of the pressure and for this reason such a possibility must be eliminated. The volumetric efficiency can be increased in two ways: by cooling the charge and by increasing the pressure of the charge. The first method was proposed some time ago. It is not being adopted because in most cases the cooling water is warmer than the atmosphere and the in-coming gas. Besides, a large gain cannot be expected, as decreasing the temperature of the charge 10 deg. fahr. could only increase the output about 2 per cent.

The other method for increasing the output, which lately has attracted renewed interest, consists in increasing the pressure of the charge and simultaneous scavenging of the exhaust gases. In this manner a given suction volume of an engine can accommodate a larger weight of charge and greater output of power can be attained.

The original purpose of this method, which has been known in England for many years, was the avoidance of pre-ignition by scavenging the cylinder of what remained of the hot exhaust gases. It is the competition into which the gas engine has lately had to enter with the steam turbine, that has brought to the front the possibility of increased power output and consequently lower cost of the machine per unit of power.

The simplest method of realizing the scheme of scavenging and charging consists in closing the exhaust valve late and opening the inlet valve early. The time during which both valves are open is used for scavenging. In order surely to avoid loss of gas, the charging with gas is only commenced after the exhaust valve is closed. At the end of the suction stroke the mixing chamber must be cleansed of combustible mixture by scavenging (rinsing) with pure air, as otherwise backfires would occur at the beginning of the next scavenging period. Gas and air are brought to the machine under a pressure of about 3 lb. per sq. in. gage. On account of this increased pressure the weight of the charge is about 20 per cent greater than that of the normal method. Scavenging the combustion chamber also furnishes further space for fresh mixture. Experiments have shown a mean effective pressure of about 100 lb. per sq. in. In continuous operation, in so far as we can speak of such in experiments, mean effective pressures of 85 lb. per sq. in. can be reached.

Undoubtedly such results present much that is attractive, especially as the output can still be increased by further increasing the pressure, and as this would give to the gas engine the capacity for overloads which heretofore it did not possess in the same sense in which steam engines do. Experiments have also proved that these overloads can be had without an increase of the maximum pressure. This is done by reducing the compression.

In spite of the lower compression the heat consumption per unit of power was not increased. It seems that this result is explained first by better combustion of the charge which is not contaminated by the remains of the exhaust gases, and secondly by a decreased percentage of loss in the cooling water. The predominating influence can only be found by means of carefully measured heat balances which at present are not available. The increased temperature of the cylinder walls, which has been found thermo-electrically, has caused objections against continued operation with scavenging and forced charge. A certain justification cannot be denied to these objections. The *decrease* of continuous loads is the very factor that has contributed to overcome the difficulties of operation. To endanger regular operation by increasing the power

output must appear to be a dangerous experiment in just such cases where the equipment is insufficient and an increase is highly desirable. The disposition on the part of operating engineers to await developments, is easy to understand. The present satisfactory operation, which is the result of years of toil, is making these engineers justly conservative.

The danger is to be found in the fact that the increase of output on one hand is offset by a decrease on the other hand on account of the more frequent shutdowns for repairs. Besides these questions, which can only be solved by several years of experience, there are other difficulties in the constructive realization of this idea of increased output which have to be solved before it is proved to be practicable in sustained operation. In a word, there are many nuts to be cracked, before we can think of a practicable increase of the power output of four-cycle engines by means of scavenging and forced charge.

IMPROVING GAS ENGINE ECONOMY

The endless desire of gas engine builders to improve the economy of the gas engine, has lately brought to the front interest in the utilization of waste heat. According to experience, a blast furnace gas engine dynamo consumes in continuous service on the average about 16,000 B.t.u. per kw-hr. Of this amount of heat only 3412 B.t.u. is converted into electrical energy. Of the balance, 12,588 B.t.u., the mechanical, electrical, and radiation losses have to be regarded as unredeemable, as well as the energy contained in the unburned gases. The heat in the cooling water, about 4800 B.t.u., and that in the exhaust, about 5200 B.t.u. per kw-hr. is, however, available for a more or less perfect further utilization. The high temperature of the exhaust, about 880 deg. fahr., measured at the exhaust flange, makes possible its immediate use for the generation of steam in boilers, which have to be placed as closely as possible to the exhaust chamber. As a matter of fact, it is possible to obtain about 2 lb. of high-pressure steam per kw-hr. of the gas engine.

The utilization of the heat in the cooling water is not possible as directly as this. The further use of this heat means the generation of steam and this requires a considerably higher temperature than that customary today in large gas engines. Semmler suggested as long ago as ten years, that gas engine cylinders be cooled with water hotter than 212 deg. fahr., and that this water be put under pressure in order to avoid the generation of steam in the jacket. Evaporation commences only outside of the jacket, when the superheated water is conducted through a throttle valve into a steam drum. It may be easily understood that this "hot cooling" scheme has been regarded rather skeptically for a long time. About a year ago it was decided at the Rombacher Huetten Werke to try Semmler's cooling method on an 800-kw. tandem engine. The results in operation, which are available today, are entirely favorable. The hot jacket not only did not hurt the cylinder, but it caused apparently a softer and more quiet operation of the machine.

The use of distilled water in a closed cycle, and the considerably higher temperature of the outer cylinder wall, which causes nearly equal average temperatures of the inner and outer cylinder walls, are surely advantages which, if the favorable experiences last, merit more consideration than the recovery of waste heat. The amount produced is in the case of the engine mentioned, about 0.5 kg. of steam of low pressure per kw-hr. There is no doubt that this figure can be very much improved by designing the cylinders more suitably for this purpose, by careful insulation and by connecting the cooling water from the piston, which heretofore has not been used.

The results achieved in recovery of waste heat will be of different practical value for different types of blast furnace plants. Where there is a steam plant in addition to gas plants, it would be advantageous to shut down some of the boilers and substitute steam from the waste heat boilers by connecting them to the steam mains, because this steam can be produced almost without cost for attendance and for fuel, and therefore, as cheaply as is possible.

DISCUSSION

H. J. Freyn. Professor Langer devotes a considerable portion of his paper to the question of regulation of large gas engines and he points out in a very able and clear manner that of the two prevalent systems of regulation of gas engines, namely: by stratification of the mixture and constant compression versus throttling of gas and air and variable compression, the latter method has proved its superiority in every instance and from every point of view.

I can but heartily endorse every statement made by Professor Langer and while in my earlier career favored the stratification method I frankly changed my mind many years ago as a result of practical experience with engines regulated on both systems.

Abroad, the leading gas engine manufacturers have for a considerable length of time adhered to the stratification principle, although choosing the more rational form of attempting to obtain stratification by arranging their valve gear in such a manner that a certain quantity of pure air always *followed* the mixture.

In this system, therefore, only one chance for diffusion between gas mixture and pure air exists, with the result that operation at fractional load was reasonably satisfactory because the danger of formation of a bad mixture during the suction and compression strokes was not as great as it is in the system where a variable quantity of mixture is "sandwiched" between two layers of pure air, causing diffusion in two planes, as it were, on either side of the mixture.

It has been my experience that gas engines operating on the so-called stratification principle, while giving excellent results from full load to approximately half load, are not capable of maintaining regular ignition upon all piston

faces as soon as the load drops below approximately 50 per cent of the rated capacity.

The influence of this phenomenon upon regularity of operation, especially if alternating-current generators driven by such engines have to be operated in parallel, is very marked and it will be found that such power plants usually show excessive cross currents and "swinging on the line" at light load. This is not the case with engines regulated on the principle of variable compression and constant mixture, and especially with those where gas and air are throttled during the whole suction stroke.

Professor Langer has very ably and comprehensively proved along theoretical lines why this should be so, and he points out especially what provision must be made in the governor gearing to bring about the desired results, not only at full load but also at fractional load.

The point of "drowning" of gas engines in gas, raised by the author, is very well taken. Gas blowing engines which have to be operated at times at reduced speed are particularly susceptible to drowning. Gas blowing engines regulated on the principle of constant mixture and variable compression are better suited for slow speed operation, as was proven in many instances in Europe where large gas blowing engines could be operated for one hour at a speed of 19 r.p.m. with full pressure of 15 lb. on the blowing cylinder.

Without a single exception, German gas engine manufacturers several years ago abandoned the stratification method of regulation and a large majority have adopted the so-called "combination system," making use of the simplest method imaginable for throttling of air and gas, viz., by the application of so-called butterfly valves as throttling and regulating organs.

These engines are regulated in the following manner. From full load down, the governor acts first only upon the gas dampers with decreasing load, while the air dampers remain in their original position. Below about 60 to 70 per cent of rated load, the governor begins, through a toggle motion, to act upon the air butterflies as well. The toggle effect is so arranged that with further decreasing load, the air dampers act more quickly than the gas dampers, so that below a certain fractional load a perfectly constant mixture is admitted.

It will be seen that this combination method of regulation combines the advantages of both stratification and constant mixture regulating methods; at the heavier loads, practically constant compression is obtained, while at the lighter loads governing is performed on the constant mixture principle.

With reference to the subject of gas cylinders, I believe that Professor Langer's excellent exposition of the relative merits of cast iron and cast steel and of the one-piece vs. the split gas cylinder deserves the careful attention of both gas engine builders and users. Professor Langer's discussion of this question is very timely, because in this country the battle between the advocates of the one and those in favor of the other is still waging.

I have had an opportunity of studying these questions in detail during the last few years and I have come to the conclusion that Professor Langer is unquestionably right in his preference for one piece cast-iron gas cylinders fitted with hard cast-iron liners. Earlier difficulties with cracking of gas cylinders have naturally led manufacturers to look for a building material which could stand up better under the strains and stresses imposed by mechanical forces and temperature variations. In Europe cast-steel cylinders were tried several years ago with the result that breaks occurred after a much shorter time of operation than when cast-iron cylinders where used. I believe that a similar experience was had in this country.

Cast-iron cylinders in one piece can be made so perfect today that they will stand up very well. At the gas engine power plant at Gary, 140 one-piece cast-iron gas cylinders are in operation, 68 of which have been in service nearly five years. Of all these cylinders only one had to be actually replaced by a new one, although at the time of installation of these particular engines, the art had not progressed as far as it has today. It is true that a number of these cylinders show fire cracks and breaks in the counterbore, but repairs have been made and the cylinders are still in perfectly satisfactory operation.

One of the most important points to which by far too little attention is paid, especially in this country, is the question of the use of suitable cooling water. Very interesting experiments were made abroad to determine the effect of the accumulation of scale on the cylinder walls and it was found that the average temperature of these walls increased at an amazing rate with seemingly unimportant deposits of scale. I know of at least one installation where thermometers are inserted permanently in the inner cylinder walls reaching to within 1/4 in. of the cylinder bore. The operator is supposed to watch these thermometers which, after the cylinder jackets have been thoroughly cleaned with wire brushes and weak acid solutions, show a gradual rise of temperature while operation continues. As soon as the thermometers show a temperature of 125 deg. cent. the engine is shut down and the cylinder walls are again carefully scrubbed and cleaned. In this particular instance the cracking and breaking of gas cylinders which had become a nuisance on account of its frequency, was entirely stopped.

Professor Langer has elaborated considerably on the question of the increase of output of large gas engines and improvements in gas engine economy. I have studied the latest attempts of European gas engine manufacturers to obtain an overload capacity of four-cycle gas engines by using the so-called scavenging and surcharging method. I have seen several installations abroad equipped with this system and I am familiar with tests made by Ehrhardt & Sehmer on engines furnished by them. They show that in spite of a material increase in mean effective pressure amounting to 25 to 35 per cent, no increase occurs in the initial pressure nor in the average temperature of the gas cylinders and other gas engine parts exposed to the high temperatures of combustion. This firm is prepared to give guarantees regarding the heat consumption of engines equipped with the scavenging and surcharging system which are not any lower than those usually given for ordinary four-cycle engines of equal capacity.

I cannot agree with Professor Langer's statement that engines operated on this principle are subject to a greater wear and tear than ordinary gas engines; the stresses and strains which the running gear and other engine parts sustain are due primarily to the initial pressure and not to the mean effective pressure. If we consider the main bearings, for instance, it will easily be seen that such a bearing will give no trouble as long as a film of oil can be maintained between bearing shell and shaft. The maintenance of such a film depends upon the amount of pressure per square inch

and not upon its duration; with lower initial pressure and higher mean effective pressure, therefore, these main bearings must give at least as good satisfaction as they are giving in ordinary four-cycle engines. As a matter of fact, the dimensions of pins, bearings, etc., of scavenged and surcharged engines have not been increased beyond those customary in ordinary non-scavenged engines.

The question of utilization of the exhaust heat of gas engines has had practically no attention in this country, and yet it is such an excellent and cheap means of increasing the usefulness of the gas engine and the financial returns from its application. I wish to refer in this connection to one of the best papers on the subject, which was read by Leon Greiner before the Liege Engineering Society about a year ago. Practical results are given which were obtained with an installation of such boilers in connection with blast furnace gas engines at the John Cockerill Works of Seraing, Belgium.

Referring to the competition between gas engines and steam turbines, I wish to call attention to my paper read before the American Iron and Steel Institute's meeting of last May, which is devoted exclusively to this subject and which proves with the aid of cost figures obtained in actual, commercial operation of large gas engine power stations in this country that gas engines operated on so-called "waste" industrial gases—an unfortunate misnomer which should be abolished as quickly as possible—are superior in commercial economy to any other known method of producing power.

F. Z. Nedden said that the present status of the large gas engine, both in Europe and in this country, is perhaps more considerably influenced by the introduction of surface-combustion boilers than implied in the paper. In this country we have very largely the use of natural gas, especially in the Pittsburgh district, which is very suitable for being used under Schnabel-Bone surface combustion boilers. One of these installed at the Shinningroove Iron Works, in England, is claimed to have given an efficiency of nearly 90 per cent, as compared with the efficiency of the ordinary boiler, which ranges from 65 to 70 per cent. That would mean that with the surface-combustion boiler the gases available in the Pittsburgh district would be able to produce one-third more power than at present. In other words, the cost of energy would in that district be reduced by about 20 per cent.

A great deal is said about the advantages of the Schnabel-Bone boiler which are naturally claimed by those interested in its introduction. Professor Langer's experiences with it would be of interest, if he would give some account of them.

To make his questions more specific, he said he would ask Professor Langer if it was true that the efficiency of the Schnabel-Bone boilers actually exceeded that of the ordinary boiler by about 25 per cent, and if that boiler was reliable in service;[1] also if the utilization of the heat of waste gases in the gas engine was possible by the Schnabel-Bone boiler?

R. H. Fernald. At a central plant in this country, built to utilize low-grade fuels at the mines, I ventured to criticise the fact that a steam plant had been constructed instead of a gas plant. The vice-president of the company said that he had wanted to put in a gas plant, but was forced to put in steam as he found no large gas producer units that would be available and satisfactory for an installation of the size contemplated. In other words, it seems to be a question of the size of the unit which is deferring the installation of plants of 100,000 to 250,000 h.p. directly at the mines. I would, therefore, like to hear from Professor Langer his opinion regarding the possible size of the large gas engine of the near future. The question, of course, arises as to what is a large gas engine. In 1900 a 500-h.p. engine was considered large. At the present time we have 5000-h.p. units. What is to be the large gas engine 10 years from now? The reciprocating steam engine was slow in developing. The steam turbine developed more rapidly than the reciprocating steam engine.

All are familiar with the relic in the yard of the General Electric Company at Schenectady—a 5000-h.p. unit which was one of the early turbines of this country. This was followed by an 8000-h.p. turbine and later by a 14,000-h.p. unit, and I understand that an order has recently been placed for a single unit of 30,000 or 35,000-kw. capacity. This steam turbine development has been very rapid.

If we are to install large central plants at the mines and develop electric current for long distance transmission we must have large gas engine units if producer gas is to compete with steam. A gas producer of 3000 to 4000 h.p. capacity in a single shell has recently been installed. The construction of the plant is so simple that the cost of manufacture should be low. If this producer meets the demand and proves to be a commercial proposition, there is a possibility of developing units of not less than 10,000 h.p. in a single shell (since these comments were made I understand that a unit of 75 tons capacity per 24 hours has been ordered), but gas engine units of a size to compete with large steam turbines are slow in developing. This central station at the mines is not pure theory. The few installations that have been made at the mines have attracted the attention of engineers and I understand that one of the large coal companies of this country is at the present time considering the installation of such a plant for the utilization of mine refuse. I was told recently that representatives of this company are in Europe seeking information relating to large by-product gas plants. I have also been told that the producer-gas interests are also alive to the situation and have sent representatives abroad within the past few weeks to study the question of large units. These large units seem essential if we are to utilize our fuel resources to the best advantage. I trust that Professor Langer can give us some definite information regarding the future of the large gas engine unit.

F. S. Giller. With reference to the point brought up about having gas-driven electric plants at the coal mines, I would like to ask whether gas engine sets, in their largest sizes, could compete with steam turbine sets, in their largest sizes, in the matter of cost of production and convenience of operation.

It is not easy to understand just what is meant by the author's statement that the gas engine is vastly superior as a fuel saver from the economic point of view. A concern handling a large power production undertaking does not consider either cost of fuel or first cost, except in their relations to the total cost of production. Undoubtedly the cost of fuel is a very important item in this total cost, but I believe that practically all of the other items, such as depreciation, repairs, rents, taxes, insurance, interest on invest-

[1] This question is very fully answered by G. Neumann's article, an extract of which appeared in the Foreign Review for January, 1914, p. 09, etc.

ments, etc., are higher for gas plants than for steam plants, and that together they usually constitute a greater argument against the gas engine sets than the high heat efficiency does for them. I have lately visited many large steam-driven and water-driven electric generating plants, and also the large gas-driven plant at Gary. At this last place, I could not help being struck by the great size of the generating sets in comparison with the sizes of corresponding turbine sets, the enormous foundations and buildings required by them, and the obvious need of a large staff of men to keep them in proper repair and operation. Undoubtedly the sets would be smaller if they were using richer gas, but I doubt whether, at the present time, the best gas engine set, working under its best conditions, can compete with the best steam turbine set, working under its best conditions. With regard to the future, the chance would seem to favor the turbine more and more, for the efficiency of the turbine is improving rapidly and continuously, whereas that of the gas engine is not so marked. The author speaks of the competition between the gas engine and the steam turbine, which lately has become very keen in Germany as well as in the United States. I am under the impression that the competition is becoming less keen and that the arguments are more and more in favor of the turbine. Several years ago, the Mond people in England were producing and distributing power gas on a large scale, but I believe their installations do not increase much, and that the progress made by gas plants generally during the last few years has not been anything like so marked as that made by the turbine, except that gas plants have been utilized in steel mills and other places where gas is to be had under unusually favorable conditions.

A comparison of the theoretical costs of production of electric energy by a large gas-driven plant and by a steam-driven plant of the same total capacity, assuming both of them to be situated at the coal pit and burning all the coal brought up from it, would be very interesting. I would like to ask whether such costs have ever been prepared and if not, whether the author considers that they would argue in favor of the gas-driven sets.

F. Z. Nedden, in reply to a question referred to the Humphrey pump recently installed in Chingford near London. The problem of using the Humphrey pump as a generator of electricity has been taken up by the Siemens-Schuckert Werke of Berlin. They are actively engaged in tests with the object of generating electricity by means of a water turbine driven by water raised by a Humphrey pump. The water after passing the turbine circulates through the pump again. So far nothing has been published as to the economy of the system. Such a plant would seem to be the proper spare for a low fall water turbine during periods of shortage in water. Instead of using a separate spare generator set driven by a steam or internal-combustion engine, the water would simply have to be pumped, by a Humphrey pump, from the tail-water back to the headwater and flow through the water turbine again, thereby saving expense for a spare generator and simplifying service.

The Author. Referring to the discussion by Mr. Freyn, while regulation by throttling the gas only will produce a smoothly running engine, I prefer to throttle air and gas simultaneously.

In reference to cylinders, cracked cylinders which have been calked have lasted a good many years and very many of them are still in use. It does not weaken or damage the cylinder if cracks are noticed soon and calked. The crack gives some relief to the lamina which is exposed to the highest temperatures and strains.

With regard to the objections in connection with the surcharging of the machine mentioned in the paper, I do not want to imply that the strains are due to the greater mechanical forces acting. There is no question that by reducing the compression pressure it is possible to work with the same maximum explosion pressure, at the same time having from 20 to 25 per cent higher mean effective pressure. The strains referred to are not caused by mechanical forces but by heating. In this matter I cannot draw on my own experience, but I have heard that the temperatures of the cylinders are increasing. This would mean an increase of strain in the cylinder walls due to the surcharging of the engines.

In reply to Mr. Nedden, I have no special information on the surface-combustion boilers. Generally it is said that the cylindrical surfaces on which the combustion takes place are filled with dust in a short time and put out of service. This, I think, is not a serious inference, since it should be possible to produce combustion cylinders at such a cheap price that it will be practicable to "scrap" them when necessary.

Professor Fernald asked about the size of gas engines. When we speak of large gas engines it means engines of 1000 h.p. and upwards. Double-acting engines of less than about 35 in. or 36 in. diameter of cylinder are not built at all, at least in Germany. The limit of the size, according to our experience there, is about 55-in. bore, by 6-ft. stroke. Tandem engines of this sort would carry a load of 3500 h.p., which means a twin unit of 6000 or 7000 h.p., about the maximum limit. This limit is not determined by shop practice or by designing, but by the impossibility of shipping by rail larger sizes of frames, cylinders and tie pieces.

I agree with Professor Fernald with regard to the production of electric power at the mines. Power can be produced at the mines for generating electricity and the current transmitted at 100,000 or 150,000 volts, which voltages I understand are being used in this country. Whether these big central stations will use gas engines or steam turbines is very hard to say; the question will probably be decided to a large extent by financial considerations.

While big units with piston engines are limited to 6000 or 7000 h.p., no limitations are given for the gas turbine, and this problem certainly represents the next advance to be made by the mechanical engineer.

In reference to waste heat boilers (in reply to a question), I cannot give the data on the necessary heating surface of these boilers. But it is not advisable to use too much of a heating surface, for it is necessary to discharge waste gases with temperatures of 200 or 220 deg., in order to prevent the condensation of the steam vapor in the exhaust gases and corrosion of the tubes, as sulphur is found in any of the industrial gases.

DYNAMIC BRAKING FOR COAL AND ORE-HANDLING MACHINERY

By Clark T. Henderson, Milwaukee, Wis.

Member of the Society

The knowledge that a direct-current electric motor can be operated as a generator and may therefore be used as a retarding device, as well as a driving means, is as old as the motor itself, and at first glance it appears strange that dynamic braking did not come into vogue until recent years. There are, in the writer's opinion, reasons for this which become apparent when the history of the art is considered. The earliest forms of coal and ore-handling machines were steam bridges or unloading towers, equipped with small capacity non-automatic tubs. In most cases these were lowered, with the hoisting engines acting as retarding devices. In cases where buckets were retarded in lowering by some sort of friction device no great amount of trouble was experienced, because there was not much energy to be dissipated. With the introduction of the automatic grab bucket the difficulties experienced with mechanical lowering brakes began to multiply, for the automatic buckets were naturally much heavier in proportion to the load handled than the small tubs which they replaced, and the duty imposed upon the lowering brakes was, therefore, greatly increased.

After the adoption of the automatic grab bucket the tendency was towards electrically operated apparatus, on which was used the retarding brake, already developed for steam plants. At first these sufficed and were considered satisfactory, but as bucket capacities increased from year to year, and the energy to be dissipated by the lowering brakes increased correspondingly, they began to show unmistakable signs of lack of ability to handle the duty imposed.

In analyzing the conditions above outlined, the underlying reasons are quite apparent: in small capacities the unit pressures on friction faces can be low, hence the wear is only nominal, and at the same time the radiating surface per watt dissipated can be sufficiently great to insure low temperature rise of parts. In large capacities, however, it becomes practically impossible to retain these proportions, on account of the apparatus becoming unwieldy. As a further disadvantage, the physical effort required to handle large friction lowering brakes is quite considerable, and it is axiomatic among designers of this class of machinery that prolonged high speed is not possible if the operator is called upon to exert any great effort.

Several builders brought out equipments on which brakes were controlled by air or hydraulic cylinders, with only pilot valves handled by the operator. These arrangements did not overcome heating difficulties, and in many cases were found unsatisfactory because of the lack of sensitiveness of control. When the operator handles friction brakes directly, he can, by sense of touch, determine when they are dragging to a proper degree, but when operated through a pilot valve, this sense is lost. It was natural, therefore, that the first 10-ton unloading machines to be electrified should have dynamic braking employed to retard the descending bucket. Manufacturers of bridges next adopted this form of control, first for ore handling and later for coal. It is now used extensively for ordinary traveling cranes, and from the present outlook it is quite possible that the mechanical lowering brake will be entirely obsolete within a few years.

On the earliest installations compound-wound direct-current motors were almost invariably employed, the shunt winding being deemed necessary to insure prompt building up of the fields. Later developments showed that series motors, the characteristics of which made them so desirable for hoisting, could be used equally well if their fields were temporarily excited just at the moment of releasing the holding brake and the excitation current cut off as soon as the machine built up as a generator. The cutting off of the excitation current is desirable, not only from the standpoint of current economy, but also from that of motor heating, for whatever exciting current is passed through the motor fields simply adds to the general heating of the machine. The use of series motors is also desirable from the standpoint of simplicity. Where compound motors are employed it is considered the best practice to leave the shunt field continuously excited and the heating consequent to the continuous excitation of these shunt windings is considerable.

Some form of holding brake must be employed in connection with dynamic braking, for while the motor acting as a generator can prevent the load from descending faster than a few inches per minute, it can never entirely stop the load, except through the aid of a mechanical holding device, which in some cases is electrically operated and automatic; in others manually controlled and non-automatic.

DIFFICULTIES ENCOUNTERED

One of the difficulties first encountered in connection with dynamic brake control systems was that the operator, who must necessarily be able to reverse his hoist motors in order to open his grab quickly and to start down without loss of time, would in many cases leave the power on almost all the way down and would in consequence race the hoist motor to such an extent as to throw out commutator bars and tear armature coils from their fastenings. Even if these things did not occur, the commutation at these high speeds was sure to be very poor, and motors were apt to flash over when the operator threw his con-

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troller back from the reverse power to the dynamic brake position. It can readily be seen that the closure of the dynamic braking circuit at a time when the armature speed was several times more than normal would cause the flow of a braking current of excessive value.

These difficulties led to the adoption of a control scheme which permits the operator to reverse the hoist motors when opening buckets and when starting to lower, and which causes the machine to operate as a motor until a predetermined speed is reached, when it automatically and without interruption of the circuit becomes a generator. This system was further perfected by the introduction of current relays in the braking circuit, with which the current of retardation can be limited to a reasonable value, and a value well within the commutation limits of the motor. As a further refinement control systems have been developed for those installations where the holding brake is automatically operated which insure the maintenance of the brake in the released position until the load has come substantially to rest.

Some plants installed during the development stage have not been as satisfactory as the purchasers had hoped. Against the later and perfected installations only two indictments can properly be drawn: (*a*) motors sometimes overheat; (*b*) machines have insufficient lowering speed.

Assuming the installation of a proper control system, the overheating of motors can invariably be traced to improper selection. Hoist motors cannot properly be selected on the basis of horsepower to be developed during the hoisting period. The service for which they are employed is so intermittent as to necessitate their selection by what is known as the root-mean-square method, or its equivalent. Generally speaking, motors required for a given hoist operating on a given cycle must have a thermal capacity which is greater by $33^1/_3$ per cent if dynamic braking is employed than will be required if the lowering of the bucket is accomplished by mechanical brakes.

Lowering speeds, possible with standard motors and dynamic brake control, never seem to be criticised except in connection with high-speed unloading plants. Generally speaking, it is not good practice to figure on obtaining lowering speeds which are greater than 200 per cent of the full load hoisting speed, unless special motors are employed, and it is a mighty good plan to figure on holding the lowering speeds down to one and one-half times full load hoisting speed if possible. The commutation of standard series wound motors of what is called the mill type (and this is the type which is generally used on coal or ore handling bridges) is not good if they are operated above 200 per cent of full load speed; furthermore the energy stored in their armatures becomes too great for rapid control when they are operated above this limit. If dynamic braking is to be a complete success on fast plants, it will be necessary for the designers of that machinery to select special slow-speed motors of the interpole type. There is little or no doubt but that with properly selected motors lowering speeds can be obtained with dynamic brake control which are just as high as those which are possible with mechanical lowering brakes. The apparatus will, however, be somewhat more expensive, and may be commercially impossible for that reason.

DYNAMIC BRAKING FOR TROLLEY SERVICE

So far we have considered dynamic braking only as applied to direct-current motors used for bridge hoist service. In some cases this form of control has been used in connection with trolley traverse motors, but for this service it is not nearly so well adapted; in the writer's estimation its fitness is questionable. In hoist service there is always a definite force (that of gravitation acting on the bucket) tending to run the hoist motor as a generator at all times when braking is required. On trolley traverse service the force driving the motor is exceedingly variable, being that of trolley inertia, and therefore proportional to the square of the trolley speed.

In hoist service dynamic braking is never required when the motor is rotating in the hoisting direction, and the reversal of the direction of rotation, before the motor is called upon to act as a generator, makes it possible for a series machine to be self-exciting without reversing the relation of armature and field, as is necessary on a trolley traverse motor when braking is to be accomplished while the motor continues to revolve in a given direction. The result is that a dynamic brake hoist controller is a much simpler and much more reliable piece of apparatus than a corresponding control for a trolley traverse motor.

The variable amount of energy to be absorbed on trolley control service and the comparatively small number of steps commercially possible make it impractical to stop by dynamic braking without making the bucket swing. Air braking, under the control of a standard railway type brake valve, providing, as it does, an infinite number of gradations of braking, is, in the writer's opinion, preferable for heavy duty, and the manually applied brake preferable for light service.

When a motor runs, say in a clockwise direction, it will be found that the best results will be obtained by setting the brushes a little ahead of the neutral point and thus giving it what is called the "motor lead." What is motor lead for one direction of rotation is "generator lead" for the opposite direction of rotation. Hoist motors can have their brushes given motor lead for hoisting and this will aid them to commutate properly while acting as generators during lowering. Any reverse power that they may be called upon to develop will be so small in comparison with that required in hoisting that their generator

lead for the lowering direction will not be found objectionable. The trolley traverse motors when used with dynamic brake control may be called upon to act either as generators or motors in both directions, and therefore cannot be thus aided. For this reason it is especially desirable to employ interpole motors when dynamic braking is used for trolley traverse control.

MISCELLANEOUS USES

In connection with car dumping machines there is no doubt but that dynamic brake control for the tipple motors is highly advisable, and so far the writer has heard no valid objections to its employment for this service. The lowering speeds demanded are never excessively high, one and one-half times full load hoisting speed invariably seeming to be considered quite satisfactory.

Dynamic brake control systems are sometimes employed in connection with car haul for pulling cars upon a dumper. In those cases where it is employed it has proved quite satisfactory. Braking is not ordinarily required when moving the mule car up the incline, and such braking as may be required in lowering is so small in comparison with the capacity of the motors necessarily employed as to make the problem an exceedingly simple one.

Of late years there has been a considerable number of bridges equipped with alternating-current motors and in some instances dynamic brake control has been employed in connection with those motors operating the hoists. The writer has not heard of any installations where this form of control is utilized in connection with trolley traverse motors.

USE WITH ALTERNATING CURRENT

A three-phase alternating-current motor of the slip ring type has to a large extent the characteristics of a direct-current shunt wound machine. Having these characteristics, it resists any force which tends to make it revolve above synchronous speed. A motor whose synchronous speed is 750 r.p.m., for example, will operate at about 720 r.p.m. when exerting full load torque. If a force equal to full load torque tends to revolve this motor above synchronous speed, the machine will develop a retarding force equal to the propelling force at approximately 780 r.p.m. On account of this characteristic, three-phase motors can be connected directly to the line for reverse operation and will prevent the lowering speed from exceeding the full load hoisting speed more than a few per cent. The motors cannot, however, be used to slow down the load, for only this one braking speed is available. On some installations attempts have been made to obtain perfect braking control by the excitation of the stator winding of the hoist motors from a source of direct-current supply.

When the stator windings are thus excited the motors act as generators and the currents set up in the rotor windings serve to retard the descending load. It has been found, however, that to bring the descending bucket substantially to rest, a very heavy exciting current is required in the stator winding. In fact, the exciting current required is so high that if prolonged for any considerable period of time, it will cause the winding to overheat. It has been necessary, therefore, to incorporate with these alternating-current dynamic braking control systems adapted to give graduated control, means for varying the stator excitation in proportion to the braking effort which the motor is expected to exert. There is one successful installation of this character with which the writer is familiar, but the maximum lowering speed it is possible to obtain is only one and one-half times full load hoisting speed. Above this speed the machine develops a tendency to run away. Then again, the machines are much slower in operation because the flywheel effect of the rotors in alternating-current motors is considerably greater than that of armatures in direct-current motors of corresponding capacity.

In conclusion, it would seem proper to state that dynamic brake control with properly selected motors is desirable on the hoist motion of all direct-current coal and ore-handling machinery; that the use of dynamic brake control in connection with trolley traverse motors is undesirable on both direct-current and alternating-current, and that the use of dynamic brake control is desirable in connection with alternating-current hoist motors, provided there is a variable excitation of the stator windings during the braking period.

REPORT ON HOISTING AND CONVEYING

A Brief Review of the Art of Hoisting and Conveying, with Discussion of Different Types of Apparatus, and Suggestions as to Equipment and Operation

A few years ago, the use of hoisting and conveying machinery was confined almost exclusively to the handling of ore and coal, while today there is hardly an industry that is not interested in the rapid and economical handling of material. High cost of labor and strong competition have increased the importance of this subject and made the material handling engineer an important industrial factor. Improvements in hoisting and conveying machinery have been most rapid where they could be applied without disturbing existing methods, but where radical changes were necessary, progress has been slower.

There are now before us far more complex problems that will require in their solution the coöperation of all interested, and your Committee, comprising engineers, manufacturers and users of hoisting and conveying machinery, desires to make itself of real service to the members of the Society as well as to the users of this class of labor saving machinery. To obtain the opinions and encourage discussions along these lines, it begs to submit the following report:

REVIEW OF THE ART OF HOISTING AND CONVEYING AT THE END OF 1912

The hoisting and conveying machine, in which the load after hoisting travels in a straight line, became important in this country in the year 1880. The earliest efficient commercial machines produced after that date were chiefly the invention of Alexander Brown of Cleveland, Ohio. Since that date the improvements have been rapid, particularly in apparatus for handling ore and coal and other bulk materials. The early machines employed buckets that were filled by hand. These have almost entirely disappeared and automatic grab buckets have taken their places. In these machines the winding machinery was installed at one end of the structure where it served to operate the hoisting and conveying ropes.

The introduction of electricity as a motive power is directly responsible for the development of the man-trolley machine. In the latter the operator as well as the motors both for hoisting and conveying are frequently carried entirely in the movable trolley.

The capacity of the hoisting and conveying machine has been greatly increased, for individual loads handled now reach 50 tons and over, and conveying speeds for lighter loads have increased to more than 2000 ft. per min.

The cableway as a hoisting and conveying machine made as rapid progress in its development as those employing rigid tracks supported by bridge structures. The span of cableways, that is the distance between two fixed towers, has reached 2400 ft. Conveying speeds of 3000 ft. per min. have been attained. The self-filling grab bucket and the self-filling scraper bucket are in common use on cableways today. The duplex cableways on power propelled steel towers as used in the construction of the Gatun Locks at Panama represent the highest development of the cableway art. The cableway has found a wide field of usefulness of its own, particularly where portability and semi-portability and long reaches are demanded.

Within the past two years the problem of package freight handling by mechanical means has received the attention of railroad and steamship companies, the manufacturers of mechanical handling appliances and public boards interested in terminal construction. Development has been principally along two lines, the overhead and the surface system, though a third, the conveyor system, has received some consideration. The conveyor system, while perhaps well adapted to certain special conditions, is believed to be not sufficiently flexible to meet the complex requirements of a typical marine and railway terminal.

The storage battery truck has been introduced and has found favor in several terminals. It takes the place of the old hand truck, making it possible for a man to travel faster and with a much heavier load, hence reducing the cost of transportation but not otherwise affecting the problem of hand labor. This truck has the advantage of easy introduction into old terminals requiring only a reasonably smooth floor. Like the hand truck, it can enter box cars and ships having side hatches.

In this connection may be mentioned the inclined elevator which has been introduced at a few marine terminals for carrying loaded trucks up a steep grade. The storage battery truck carrying a light crane has also been introduced, but up to the present time has not found a broad field of usefulness.

The overhead monorail system is being pushed by several manufacturers and is looked upon favorably by many interested in terminal development. It is not a new device but is rather the application of an old device to a new field, for it has long been used to a limited extent in industrial plants. Its introduction into the field of freight handling has resulted in some interesting improvements, especially in track and track switch systems.

Report of Sub-Committee on Hoisting and Conveying. Presented at the Annual Meeting, December 1913, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York.

Ingenious devices have been worked out for throwing the switch to the desired position and automatically placing a stop at the open track end by the approaching trolley. One system lately introduced avoids the use of any moving part in the switch steering mechanism carried by the trolley, enabling the operator to take any desired course through the switch without stopping.

An overhead system which has been used to some extent in Europe and which has its advocates in this country, employs what is termed the gliding switch. It has a curved switch member which slides along the main track. It permits a trolley to pass from the main track to the traveling cross track at any position. This switch is, as far as the main track is concerned, a derailing device. It is believed by the Committee that no installation of this type has been made on this side of the Atlantic.

Several installations of monorail systems for handling package freight have been made in this country, one at St. Louis of considerable size and another at one of the railroad terminals at Baltimore. These installations were made previous to 1912 and afford an opportunity to study the problem with a view to determining the type of terminal and layout of monorail system best calculated to produce the desired results of speed and economy.

An overhead monorail installation was made at the Baltic terminal, New York, in 1912, which handles freight both ways between vessels, warehouse, and a freight shed alongside a railway track. The system passes over streets and tracks at a suitable elevation so as not to hinder in any way the traffic on the ground level.

Another monorail system has been installed in a large wholesale warehouse in Los Angeles, Cal., which combines the handling of package freight from box cars to warehouse and thence for delivering by automobile trucks. A system of elevators permits the trolleys to be transferred to any one of five different floors, and extensions of the tracks over the street make possible the direct loading of automobile delivery trucks. These trucks are designed with removable bodies which are loaded in the warehouse and conveyed by the trolleys to the automobile trucks. Thus a shipment may be loaded on the fifth floor of a building and carried direct to the delivery automobile truck where it is placed intact without rehandling.

The removable bodies are equipped with small wheels so that the trucks themselves may be pushed about like ordinary hand trucks. A system of this type serves as a good demonstration of the saving in freight handling costs that could be made if railroads delivered freight to the address of the consignee.

In the present development stage, the storage battery truck and the monorail overhead system appear to be competitors for the field. Certain advantages and limitations of each are recognized. The battery truck as mentioned above will enter box cars and side doors of ships. It will go anywhere a smooth floor is provided, but it will only transport and will not hoist.

The overhead system involves greater initial cost. The trolley will go only where track is provided and will not enter box cars, but it will serve flat cars and may reach out over a ship, serving any hatch or the dock without regard to level as affected by stage of tide. It will hoist as well as transport, thus providing a means of transferring freight from one floor to another, and with the traveling cross track will serve areas and tier freight. The monorail trolley affords higher speed of travel than the battery truck. As it does not require clear floor space for a roadway, more floor is available for checking, storage, etc., and the capacity of the terminal materially increased. This increase in capacity should in a great measure, and perhaps fully, justify the greater outlay. It is probably a safe prediction that the two systems, the overhead and the surface, will supplement each other, though different local conditions may sometimes control.

Coöperation between railroads, steamship and dock companies, and machinery manufacturers is absolutely essential to the best results in the development of devices for the mechanical handling of freight. Modifications and improvements in the organization and management of terminals must of necessity be made coincident with the installation of the hoisting and conveying appliances in order that such machinery may best serve its purpose.

In the past year the mechanical handling of lumber has received considerable attention. This is particularly true on the Pacific coast, where extensive preparations are being made for handling the large increase in business that is predicted will result from the opening of the Panama Canal.

The unit system of handling lumber is becoming more and more general. By the unit system is meant the sorting and stacking of lumber in uniform units which may be separated by skids or chocks, and one unit or package handled at a time. Modern hoisting and conveying appliances are equipped with automatic grapples so that these units may be picked up or deposited by the operator in the hoist. The units will range from 3 to 8 tons.

In this work the monorail man trolley has been a recent and important development. The locomotive crane has also found a field in this branch of industry and in some cases the locomotive crane of the portal pier type is needed, so that freight cars may pass between the legs of the cranes and be loaded and unloaded by it. This type of crane is designed to travel along the face of the dock for handling lumber directly to and from boats, and by means of a transfer table the crane may be switched to branch tracks for the handling of lumber to and from storage piles.

Probably the most radical development in the lum-

ber handling industry is that which the C. A. Smith Lumber Company of California have undertaken. The unit system is employed and the lumber is handled by various types of cranes. Cantilever cranes are used on the dock face for loading specially constructed vessels for the trade, which enable the large 8-ton units of lumber to be stowed intact. This means of direct handling of large units, and the development of special vessels to facilitate handling most nearly approach the history of the development of the coal and ore handling business on the Great Lakes.

We find also that during the year 1912 portable cableway log skidders have been produced and many have recently been installed in the mountain regions of North Carolina and Virginia. The features of this apparatus are: (*a*) the power plant is entirely mounted on a special railway car equipped to be coupled into a train of cars and shipped anywhere on a standard gage railway; (*b*) the car carries, besides the operating machinery, boilers, etc., a tower which will clear the tunnels of the railroads. A portable tower is added when the machine arrives on the logging railroad and a steel portable spar, which comprises the head tower of the cableway, is raised when in use and lowered when moving. A tree is used for the tail tower. Spans of 2000 ft. have been successfully employed bringing in logs from inaccessible places and thereby reducing the cost of logging by the saving of railroad building.

Two novel forms of cableways have reached their perfected stage during the year 1913. Both of these are for use on the high seas, one for trans-shipping coal, ammunition and supplies to warships in mid-ocean under headway, and the second for trans-shipping persons from a wreck to a life-saving ship.

The apparatus for coaling at sea has been under development for over ten years but not until the last year, and since the newly developed automatic tension engine has been added, can the marine cableway for coaling at sea be regarded as a complete solution of the problem. During recent tests at sea a collier, while rolling 20 deg. in a driving storm, trans-shipped 83 tons of coal in an hour to a battleship 400 ft. astern of the collier while both were proceeding at a speed of about 7 knots.

The life-saving machine comprises the old-fashioned breeches buoy apparatus, in common usage along the coast, in connection with a small sized automatic tension engine serving to wind in and pay out the main supporting cable or hawser serving as a trackway for the passage of the breeches buoy from ship to ship.

The year 1912 also marked the completion of an extraordinary group of four cableways employed for building the Tunkhannock bridge on the Delaware, Lackawanna & Western Railway. The chief novelty arises in the employment of a center tower 230 ft. high serving as a tail tower for the cableways in line. A further novel feature of these four cableways is in the equalizing apparatus to save the strains upon the guys of the central tower. The hoisting speed is 200 ft. per min. and the conveying 1800 ft. per min.

During the year there have been installed on the Sag Channel, a branch of the Chicago drainage canal, three different types of drag line excavators consisting of an elaborate crane with a boom 100 ft. long, capable of digging, hoisting and swinging, and dumping at a point 200 ft. back from the center of the canal. These long arm excavators are reported as showing a capacity of approximately 50,000 cubic yards per month, working 24 hours a day.

During 1912, the conveyor field was marked by little change except plants with larger capacities than in the past both in chain and belt conveyors.

One development which is of interest was the successful demonstration of the possibility of storing material in open piles on the ground and withdrawing same by tunnel conveyors. The plant in question handled 6-in. limestone which was put into storage by a 40-in. belt conveyor equipped with an automatic tripper and carried by a steel structure. The concrete tunnel under the pile housed a 44-in. belt conveyor and duplex gates in the roof of the tunnel allowed the stone to flow to the belt by gravity. There were successfully handled through a single duplex gate 1300 tons of stone per hour. This type of storage costs about half of the same capacity in bins and in this case replaced bins on a dock, the stone from open storage being carried to the vessels by 44-in. belt conveyors. Seven thousand tons were loaded without difficulty in six hours. This scheme of carrying a large storage on good ground, thus reducing the cost of the dock, is a distinct step forward, particularly where rapid loading is required and where the supporting of heavy loads involves expensive dock work.

The second important development in this industry is the extension of the use of conveyors in preparing copper blast-furnace charge. The old methods of spreading the charge on the ground by barrows or by cars into bins was inaccurate and expensive, while the conveyor method is automatic and a continuous sample being taken, the exact chemical contents of the charge are known. This improvement has reduced the cost of preparing the charge from 10 to 15 cents per ton. Two large installations in Arizona during 1912 involving an expenditure of nearly $400,000 are evidence of the fact that smelter engineers are recognizing the importance of using improved automatic machinery.

Data. As there are few accurate published data concerning capacities, weights, power formulae, etc., of conveyors and elevators your Committee would urge the engineers in this field to present such data through the Society. These data will be of inestimable value to the engineers designing plants, enabling them to choose the proper type of conveyor and to pass intelligently upon the designs submitted.

These installations do not by any means cover the field of development, and the Committee invites members to forward brief descriptions of other interesting and novel installations in the field of hoisting and conveying.

RECOMMENDATIONS AND SUGGESTIONS

Boilers. It is not the desire of the Committee to decry the formation of stringent boiler laws, but it urges that if state and city boiler laws were standardized it would reduce the cost and permit the shipment of a boiler from state to state. It would further make it possible to carry boilers in stock ready for quick shipment. This subject has been considered by the American Boiler Manufacturers' Association at its New Orleans meeting, March 1912.

At present we have a national uniform law pertaining to marine boilers, their construction, inspection, etc. All boilers used in navigation and on navigable waters of the United States come under the Steamboat Inspection Service of the United States Government, with headquarters in Washington. Facts have proved that this national uniform law has been good, and under it there have been few accidents.

Locomotive boilers by force of circumstances come under the jurisdiction of the United States Government through the Interstate Commerce Commission. This commission is divided into districts, and the inspection is uniform.

The state of Massachusetts has an excellent boiler law, and Ohio has just adopted a similar one. Chicago, Philadelphia and Detroit each have their own ordinances regulating boiler construction, all with the result that boilers built to the requirements of Chicago might not pass inspection in other cities.

Your Committee offers the suggestion that if the influence of The American Society of Mechanical Engineers is brought upon the proper authorities, improvements in standard boiler laws must be obtained.

Electric Equipments. The uniformity of all laws of this character is essential both to the builder and the buyer, and we again urge that steps be taken by the Society as a body, to further reforms in this direction.

Safety. Your Committee urges that much can be done by providing better protection of human life, and deplores the great number of accidents that have been caused in connection with the operation of hoisting and conveying machinery. The chief reason for neglect of this phase of the art is that purchasers of hoisting and conveying machinery have not been willing to recognize such additions and refinements where these have added to the cost of the machines. It urges that the question of safety to human life be conscientiously considered by manufacturers, engineers and purchasers.

Your Committee recommends that ladders be abandoned, where possible, and stairways with hand rails substituted; that all platforms and walks be provided with double hand rails, toe boards, etc. Where ladders are unavoidable they should be enclosed by lattice work or bars to prevent employees from falling in case of losing hand or foot holds.

Foundations. Much blame has been put upon builders of this heavy hoisting and conveying machinery on account of inadequate foundations. Builders of hoisting and conveying machinery seldom design the foundations for their machinery. The design of foundations for big installations comes within a field of foundation specialists who, if employed by purchasers, would obviate many difficulties which might arise.

Many docks and storage areas bordering on rivers and lakes, designed for carrying large quantities of bulk materials, have not received the attention in this particular that they should. In many cases expensive concrete dock walls and piling have been pushed out into the rivers by the pressure of the loads carried on the area in the rear. This is particularly true in stock yards around the Great Lakes.

Hoisting and conveying machinery should be designed to take care of a reasonable amount of distortion, but it is not reasonable to expect that these massive structures, many of them weighing over a million pounds, can have an unlimited elasticity as to distance between supporting rails. Disregard of suitable foundations results in broken wheel flanges, distorted structures and increased power for propulsion.

Depreciation. Your Committee finds that some of the largest and most expensive hoisting and conveying machines installed some ten or twelve years ago, are today showing signs of weakness. This indicates that the manufacturers and designers did not anticipate the use (and abuse) that this class of machinery was to receive. Many machines have been designed, sold and guaranteed for a certain capacity, which later developed capacities nearly double that originally contemplated, and carried loads far in excess of those originally estimated. Users do not hesitate to increase the weights of buckets and loads to such an extent that factors of safety are dangerously reduced.

Such use helps to depreciate the machines and endangers human life. Purchasers frequently fail to appreciate the great damage to structures caused by the passage of loads at high speed from rail end to rail end. Well designed and efficient machinery, having due regard to human safety and the reduction of costs of upkeep, will many times repay the purchaser.

Wheels. Your Committee finds that the data concerning track wheels for heavy hoisting and conveying machinery are most limited, both for rolled steel or chilled cast-iron wheels. The Committee invites papers bearing on this important subject.

Brakes. In many hoisting and conveying machines in the past, working to their utmost capacity, the brakes showed need for improvement. Some showed

inadequate provisions for the dissipation of the heat developed, others were too short lived. It is no small undertaking to lower a 20-ton load at the rate of 350 ft. per min. once every minute. The dynamic brake has recently taken a prominent place in the control of loads.

Wire Rope. Your Committee urges the importance of the selection of wire ropes and the design of structures to obtain the greatest life from ropes in service. The transportation of heavy loads together with the limited space for the installation of the operating machinery produces elements which are most destructive to the wire ropes. Ropes become an expensive factor in the operation of machinery of this class. A valuable paper on this subject was recently read before the Institution of Mechanical Engineers of Great Britain, and a digest of it should be before designing engineers. The durability of wire rope is of great importance to all users of hoisting and conveying machinery, and any paper treating exhaustively of this subject would be welcome. Such a paper should bring out the relationships between the diameter of the rope and the sheave over which it is to travel, the diameter of the individual wires in the rope, as well as the relationship between the diameter of the rope and the angularity of the bend when working over a sheave. It would be most desirable to obtain proper specifications for wire ropes for use in hoisting machinery and suitable tests to establish its values.

Ethics. Your Committee urges that the drawing plans and specifications prepared by any engineering concern are the property of the concern producing them, and holds that buyers should receive such in confidence, decline to exhibit them to others, refuse to permit them to be copied or used by any (but the owner) for purposes of construction.

It recommends among engineers that a uniform clause be embodied in all proposals requiring the return of blueprints, drawings and specifications to unsuccessful bidders, and furthermore, that all information submitted for consideration be regarded as the property of the manufacturers and be treated in confidence.

Pirating of ideas is regarded by the Committee as dishonest, and in the end works to the detriment of the buyer as well as to the engineering firms, for it is clear that the most efficient machines are likely to be produced by the mind that created them rather than by the manufacturer animated purely by the desire of pecuniary profit.

The history of nearly every important improvement in the development of the art of hoisting and conveying shows that the engineer freely laid his plans and ideas before the prospective user, both being masters in their own particular field. In order to develop what is required by the producer, complete co-operation between the two is of the utmost importance.

Your Committee recommends to all the departments of the United States Government that in asking for proposals, they insert in the invitation that the drawings and blueprints, and all data of a confidential nature shall be retained in confidence and returned to unsuccessful bidders.

Respectfully submitted,

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Alex. C. Brown
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A. L. Roberts
Harry Sawyer

Sub-Committee on Hoisting and Conveying

DISCUSSION

Spencer Miller in presenting the report for criticism asked if it were too voluminous; should it be further condensed? Should it be elaborated? Should it be illustrated? He said the committee desired to be of real service.

William Kent said he desired to see the report extended and illustrated, and that the committee should take one year or two years, if necessary, to do it. The monorail conveyor should be considered and facts regarding it incorporated in the report: what were the limitations of the monorail conveyor, where it should be used, and what were the economical loads. Illustrations showing actual installations should be given, with sizes of bearings, troubles from lubrication, friction, etc. Sketches of the various kinds of monorail conveyors should be shown with the defects of each. This applied to the belt conveyor also.

The committee should then take up the problems yet to be solved in conveying, such as getting packages out of the hold of a steamer and putting them into a warehouse in West Street, or the Bush Terminal, or some other place. That whole problem was now being handled in the most crude manner, and if the committee would take up the matter, they would perform a great service for commerce and engineering.

D. M. Myers was pleased to see the reference in the report to the matter of uniform boiler inspection, and hoped that everything possible would be done by the Society to forward safety in boiler manufacture and inspection.

Spencer Miller was obliged for Mr. Kent's suggestions as to the field in which the committee could do further work, and said it would go as far as it could.

BUSINESS TRAINING FOR THE ENGINEER

Abstract of Address by Dr. Alex. C. Humphreys at the Philadelphia Meeting, February 9, 1914

A meeting of the members of the Society in Philadelphia in coöperation with the American Institute of Electrical Engineers was held on the evening of February 9, at which there were addresses and a general discussion on the subject of Business Training for the Engineer. The principal paper of the evening was by Dr. Alex. C. Humphreys, Past-President of the Society. Dr. Humphreys said that this country is facing many problems which must be solved wisely if our government as a government of the people, for the people and by the people, is to persist. A large majority of these problems have to do with public utilities and the industries in general where expert advice is required. They would not now be so threatening if the members of our profession had better appreciated their responsibility in connection with them and had been diligent to equip themselves to meet this responsibility. So many engineers have failed to realize this situation or have been disinclined to consider the business features of engineering, or even to familiarize themselves with the principles of accountancy and business administration, that it is difficult to educate our legislators and laymen in general as to the legitimate claims of investors whom engineers are called upon to represent. No doubt it is also in part due to these causes that so few engineers are appointed on public service commissions, a service for which the broadly trained engineer is peculiarly qualified.

Dr. Humphreys asserted that he had had to meet many objections to his plans to give to engineering students instructions in the fundamentals of business practice. During his presidency of Stevens Institute of Technology he had developed a course in business methods in which the student had to take up not only the business features of engineering practice as a theory of study, but before they could graduate they had to pass an adequate examination in the elements of accountancy, depreciation, the accountancy of depreciation, analysis of data, investigations, estimates, contracts and appraisals; but they also had special lectures on the law of contracts, patent law, employers' liability and workmen's compensation, shop cost, the elements of banking and the like. While no such course could give the engineer anything like a complete equipment on the business side of engineering, this could also be said as to the curriculum in its every feature. The engineer student must study in the school of experience and unless he did he must remain as a humble follower in the ranks of his profession.

This meeting was briefly reported in The Journal for March. The complete report may be consulted in the rooms of the Society, 29 West 39th Street, New York.

Dr. Humphreys further said in part: We are all prepared to admit that an engineer should be qualified to make a correct and fully inclusive estimate of cost of construction and installation; and most of us will admit that he should also be qualified to estimate the results in dollars and cents to be reasonably expected from his work as a designer and constructor.

How can an engineer best check up his estimates as to construction and operation? By comparing the established facts with his estimates. Can he do this if he is not qualified to take full account of business conditions in his estimates? And can he do this if he is not qualified to analyze correctly the statements as compiled from the statistical books and the books of account? My answer is that he cannot make such comparisons correctly and completely, for two reasons:

a he is likely to omit from the comparisons items of cost for which he assumes he is not wholly or in part responsible

b he is not sufficiently familiar with the language of accountancy to be sure of the value of the comparisons made by others for him.

The best means at the command of the engineer to qualify himself further for the making of correct and completely inclusive estimates is the comparison between his estimates and the actual results obtained. Ordinarily the engineer makes such comparisons, but the question is, Are they made completely unless the business features of the enterprise are fully included?

In order to meet the requirements which are daily becoming more pressing, the engineer of today must not only be able to obtain good results in construction and operation, but to record those results so that the records are self-explanatory to the man competent to analyze them. This is the test under which many an otherwise competent engineer fails. It can hardly be denied that the man who does so record, analyze and compare his results is seldom an extravagant constructor or operator. If the engineer is to record his final results accurately and completely, so that those results can be understood by others to whom he may be responsible, there is only one language which is universal, and that is the language of accountancy.

As to the value of accountancy to an engineer, let us suppose that he is called upon to examine into the value of a manufacturing property, and that there are presented to him a ledger trial balance, a profit and loss statement, and a statement of assets and liabilities. It goes without saying that if he is to make an authoritative report he must understand how these statements are produced and how they are related to each other; and this he cannot do without a knowledge at least of the principles of accountancy. It may be replied that in this work the engineer can be associated with an accountant, or that his responsibility is confined to the strictly engineering side of the proposition. Then the accountant must have a sufficient knowledge of the

practical or engineering side of the business to ensure that the report as a whole shall be conclusive. This puts the engineer in the subordinate position, a position to which he too frequently seems willing to submit. The fact is that many such reports fail to coördinate because there is no such combined knowledge on the part of either the engineer or the accountant.

A knowledge of accountancy is particularly convenient in one direction, if not actually necessary, namely, in differentiating between repairs or renewals and extensions or improvements. If under the heading of repairs or renewals, extensions or improvements are charged too liberally to operation, the capital accounts may be unduly written down. On the other hand, if repairs and renewals are charged to extensions, the statement of profits is misleading and the capital accounts are unwarrantably expanded. The ability so to discriminate is a necessary qualification in the engineer-manager.

This brings me to the question of valuation of properties, which is becoming such a burning question today. Probably no one element in this subject of valuation is as important or as difficult as that of so-called depreciation. The engineer may consider that he can have a sufficient understanding of the subject of depreciation without a knowledge of the principles of accountancy, but I am confident that no man can be in a position to meet effectively the arguments of others in regard to depreciation, estimated and actual, unless he has a knowledge of the principles of accountancy. If I may judge by my experiences, it seems to be almost impossible for the man without this knowledge to appreciate that there is a sharp distinction always to be drawn between estimated depreciation and actual depreciation.

It is a fact to be deplored that not a few engineers have helped to create the confusion that now exists with regard to the difference between estimated and actual depreciation. Recently, in discussing a paper on this subject, presented before the American Society of Civil Engineers, I expressed regret that the term "depreciation" had ever been employed in this connection, and I suggested that if we would cultivate the use of the term "final renewals" instead, we should be less perplexed. Undoubtedly depreciation to accrue, namely, the cost of final renewal of plant or part of plant in consequence of physical decay, obsolescence, or inadequacy, should be covered by estimate as far as possible, so that the burden of the loss can be more evenly spread over the years of service of the plant to be renewed. In any case the cost will fall on the business, but to enable us to determine year by year what are our actual profits as differentiated from the profits which are apparent on the surface, we must take into account all accruing gains, and especially accruing losses. Otherwise we may pay out as profit that which has not been earned, and we may permit to accumulate a financial burden which we may be unable to carry when the day arrives for the final renewal of the plant or part of plant.

But in a rate-making case this does not necessarily involve the proposition that the plant as a producing agent is reduced in value to the extent of the final renewal reserve, nor does it, in my opinion, furnish the slightest warrant for adding the amount of this reserve in valuing the property as a going concern. The question of deduction from appraisal of cost new of plant in a rate-making case must not be confounded with the same question in valuing a property in connection with change of ownership. In a rate-making case the liability for final renewals remains with the present owner. If the valuation is made for purchase and sale, that is, in connection with change of ownership, the seller should make allowance to the buyer for the *liability* the latter assumes for the cost of final renewal; but even this is not necessarily the amount shown in the final renewal reserve. In fact it would be remarkable if there were such an agreement in the case of a well managed business, for as prudent operators, we should be on the safe side in estimating all of our certain, probable, and possible, accruing losses; and this can only be done with respect to final renewals of plant by making certain assumptions as to length of service, character of maintenance, chances of obsolescence and inadequacy, and methods of accounting to be followed.

The foregoing relates to what is sometimes known as "estimated depreciation," namely, the accruing loss for the final renewal of plant in addition to the current losses for maintenance; now as to "actual depreciations":

If, at any given time, it becomes necessary to value the plant itself, we have the plant before us; we are informed as to present demands made upon us by the business. We are able, therefore, to determine whether the plant is adequate or inadequate as to capacity, and are able to determine its condition as to obsolescence. Why then, in trying to determine the present actual condition of the plant, with the plant and business records before us, should we depend upon an estimate made perhaps years before (or some previous year) as to what would be the condition of the plant in years to come? The actual facts can be determined only by an adequate examination of the plant by those competent as constructors, as operators, and as administrators.

Coming back to the question of accruing depreciation, or reserve for final renewals, there would be no necessity to make any estimate thereon if we were convinced that the plant year by year is having spent upon it, not only for repairs and current renewals *but for final renewals*, an amount which keeps the plant up to its full original value; that is, if the asset value is being maintained as a whole. For instance, suppose that the ties of a railroad are found to have an average

life of ten years, and it is also found that, taking in the main line and all subordinate lines, about one-tenth of the ties are replaced each year; then there is no need to charge up anything for accruing depreciation on the ties as a whole because the average final loss is currently being met.

This gives an opportunity to point out a serious error in rate-making cases, as made even by engineers of reputation, in confounding accruing depreciation as estimated in connection with loss and gain account, and actual depreciation in connection with a valuation. In the case of the railroad ties referred to, certain engineers of repute have claimed that in this case the ties in service would have a remaining average life of only five years and therefore 50 per cent should be deducted from the cost new to cover depreciation. This spells confiscation as far as that part of the plant is concerned; and in this case I hold that if such a claim is allowed we should be permitted to introduce in the estimate of cost new a like amount as an overhead charge, for the reason that this 50 per cent is thus declared to be a necessary loss in connection with the construction and maintenance of the plant.

This leads to a very brief consideration of so-called overhead charges, items wholly or in part which too often the engineer fails to include in his estimates. By some the items of omissions and contingencies are considered as overhead charges. I consider them items of construction, for while we may not be able to estimate these items of cost accurately, we may be sure that there will be items of cost under these two headings. There never was constructed a plant of any size, which, when it was finished, did not contain parts which were not included in the original estimate. Furthermore, we must be prepared for contingencies in connection with almost any construction of magnitude. And yet there are so-called experts who claim that in valuing a plant as it exists, if we make an inventory and put against each item in that inventory the cost of reproduction, the cost as a whole is covered. No man who has had experience as a constructor and who will look back upon and analyze his experiences can honestly endorse such a claim. To commence with, no such inventory is ever absolutely complete. But suppose it to be complete as far as possible, no such inventory would ever include all the items which have necessarily gone into and have been covered up in the construction of the plant.

There are other items which must be included in the final cost, call them overhead charges or by any other general title. These may be summarized briefly as follows: Preliminary expenses and surveys, interest and taxes during construction, engineering and inspection (strangely enough, an item not infrequently omitted by the engineer), business organization during construction, fire and casualty insurance, cost of development, cost of financing.

NECROLOGY

EDWIN M. CORYELL

Edwin M. Coryell was born in Brooklyn, N. Y., September 25, 1847, and was educated in the public schools there. After three years as apprentice and draftsman, in 1869 he started out for himself as mechanical engineer, patent attorney and draftsman in New Haven, Conn. Two years later he secured employment at the Bessemer Steel Works, Troy, N. Y., where he came under the personal direction of Alexander L. Holley and was fellow draftsman with Allen Sterling. He served as draftsman at the Providence Steam Engine Works as well as on the Brooklyn Bridge, and from 1878 to 1879 was draftsman with the New York Gas Light Company. For the last 34 years Mr. Coryell had been connected with the A. S. Cameron Steam Pump Works, first as draftsman, then as salesman, assistant superintendent, superintendent and finally as consulting engineer. During that time he invented more than 200 patented devices for pumps and other machinery. He died suddenly on March 23, 1914.

WALTER LAIDLAW

Walter Laidlaw was born in Scotland in 1849. In his youth he served an apprenticeship of four and one-half years as machinist with James Sheil, maker of machinery for the manufacture of Scotch-Tweed engines, water wheels, shafting and gearing. This course was supplemented by one and one-half years service as an "imperial erector" with Caird & Company, shipbuilders and engineers, Greenoch, Scotland, in which position he was engaged in the erection of first-class ocean steamships. He next entered the engineering department of Trinity House, a body which has official charge of the lighthouses of Great Britain. He served as engineer and chief engineer for ten years and worked in this most interesting period of lighthouse development shoulder to shoulder, first with Prof. Michael Faraday, who was scientific advisor to Trinity House, and later with his successor, Professor Tyndall; he also enjoyed the acquaintance and at times coöperation of Lord Kelvin in some of these developments. While in this service he drew the specifications and purchased the first direct-acting generator ever used for lighting, which he installed and for a while operated in the lighthouse at Lizard Point, where it is still in satisfactory operation as an auxiliary.

Mr. Laidlaw came to this country in May 1881, and entered the employment of the Lane & Bodley Company of Cincinnati. After two years with this company, he accepted a position as constructing engineer with the Procter & Gamble Company of Cincinnati, to design and construct the extensive new factories which they were then preparing to build at Ivorydale, near Cincinnati. Mr. Laidlaw remained in charge of this work until 1887, and had the satis-

faction of bringing to completion one of the most complete manufacturing plants in this country.

In 1887, with the completion of the Ivorydale plant, Mr. Laidlaw assisted in organizing the Laidlaw & Dunn Company, afterwards the Laidlaw-Dunn-Gordon Company of Cincinnati, manufacturers of steam pumping and hydraulic machinery. With the formation of the International Steam Pump Company in 1899, Mr. Laidlaw was continued as manager of the Cincinnati plant. In 1908 he became general manager of the Snow Steam Pump Works at Buffalo, N. Y., and in 1909 a member of the executive committee of the International Steam Pump Company, making his headquarters at the head office, New York City. Shortly afterwards, he became secretary, and later director, of the International Steam Pump Company, and vice-president of the Laidlaw-Dunn-Gordon Company, positions he retained until the time of his death, March 25, 1914.

During the latter part of his life Mr. Laidlaw realized the full development of his engineering abilities, and became greatly interested in the technical education and advancement of young men. It was largely through his efforts that the Ohio Mechanics Institute was placed upon a solid basis and began its successful expansion. He served at one time as president of the institute and recently stated that one of the most pleasant memories of his life was his privilege, in that capacity, of awarding the diplomas to the young graduates in whom he had taken so much interest, and seeing them started upon their life work.

Mr. Laidlaw was Manager of the Society from 1905 to 1908, and was a member of the Engineers Club of Cincinnati, Engineers Club of New York, Manufacturers Club of Cincinnati, Cincinnati Chamber of Commerce, and of the Board of Managers of the Society for the Promotion of Industrial Education. He was a man of widely varied interests and activities, but bringing to all of them a degree of calm and far-seeing judgment, tolerance and a breadth of ideas which will be as much missed among his associates, as his characteristics of high personal integrity and invariable kindliness and helpfulness of disposition.

ALFRED NOBLE

There passed away on April 19, 1914, in New York City, Alfred Noble, an esteemed member of our council and a man whose loss will be deeply felt and deplored not only by the engineering profession of which he was one of the most distinguished members, but by everyone who had the good fortune to know him.

He had a very interesting career, and the story of his life, if adequately written, would be typical of that of many of the great men and builders of this nation.

He was born August 7, 1844, at Livonia, Wayne County, Michigan, where his parents resided on a farm. His early education was received in the district school of his native place, and during his spare time he worked on the farm.

In 1862, when only 18 years of age, he enlisted in the Civil War in the 26th Michigan Volunteer Infantry. From that time until 1865 he served in the Army of the Potomac, taking part in all of the hard and desperately fought battles which that army engaged in against Lee and Stonewall Jackson. At Gettysburg his regiment lost a very large percentage of its numbers. At Chancellorsville, it was by the merest accident that his brigade was not captured by Stonewall Jackson's men, but he was lucky in serving through the war without being wounded, and was mustered out of the service in June 1865 with the rank of sergeant. He then prepared to enter the University of Michigan, and in 1867 became a sophomore, graduating in 1870, with the degree of C. E. He received the degree of LL.D. from his alma mater in 1895, also from the University of Wisconsin in 1904.

From 1868 to 1870 he was assistant engineer on river and harbor work on the Great Lakes. From 1870 to 1872 he was in charge of improvements on St. Mary's Falls Canal and St. Mary's River. During this time the first great masonry lock at the Soult, then by far the largest canal lock in the world, was built. On completion of this work he became resident engineer on the construction of an important bridge at Shreveport, La., over the Red River.

From 1883 to 1886 he was general assistant engineer on the Northern Pacific Railroad, and from 1886 to 1887 resident engineer on the construction of the Washington Bridge over the Harlem River, at that time the largest arch bridge in existence.

From 1887 to 1894 he was resident engineer on the construction of several very large and important bridges over the Mississippi at Memphis and Alton, over the Missouri at Bellefontaine and Leavenworth, over the Ohio at Cairo.

He was appointed a member of the Nicaragua Canal Board by President Cleveland in 1895. This board visited Central America and examined the route of the Nicaragua Canal and also the Panama Canal and then returned to the United States, completing its work November 1, 1895.

In June 1899 he was appointed by President McKinley a member of the Isthmian Canal Commission which was charged with the selection of the best canal route across the American isthmus, and it has been substantially on the route selected by this commission that the Panama Canal has been constructed. While on this commission, Mr. Noble with his colleagues visited Europe to examine the existing canals there, and the data which the French Canal Company had in Paris, and also made several trips to Central America to examine more fully the various canal routes.

In 1905 he was appointed by President Roosevelt a member of the International Board of Engineers to

recommend whether the Panama Canal should be constructed as a sea level or a lock canal. This board consisted of thirteen members, of whom five were nominated by foreign governors. Mr. Noble was one of the minority of five Americans who recommended the adoption of the lock plan. Their views were adopted by the Government and the canal has been built in accordance with their recommendations. In March 1907 he was one of the three appointed by President Roosevelt to visit the Panama Canal to investigate the conditions regarding the foundations of some of the principal structures. This duty was completed in a few weeks. He was obliged to decline a similar appointment two years later.

From the very inception of the plan by this country to build an Isthmian Canal, and from the commencement of the preliminary investigations and surveys, to the adoption of the final plan and the beginning of the actual construction of the Panama Canal, Mr. Noble was continuously identified with the project and deserves as much credit for the solution of the engineering problems as any other one who has been connected with this great work.

In July 1897, he was appointed by President McKinley, a member of the United States Board of Engineers on Deep Water Ways, which made surveys and estimates of cost for a ship canal from the Great Lakes to deep water in the Hudson River.

In November 1901, the city authorities of Galveston, Texas, appointed Alfred Noble along with Henry C. Ripley and General Robert, as a board of engineers to devise a plan for protecting the city and suburbs from future inundation. They recommended the building of a solid concrete wall over three miles long and seventeen feet in height above mean low water, the raising of the city grade, and the making of an embankment adjacent to the wall; the whole to cost about three and a half million dollars, which plan has since been carried into effect.

From 1902 to 1909 Mr. Noble was chief engineer of the East River Division of the New York extension of the Pennsylvania Railroad, and was in entire charge of this most difficult piece of work, involving as it did, a very accurate survey across Manhattan, and the construction of the foundations of the Pennsylvania Station, of the land tunnels, and of the East River tunnels which were very troublesome.

Since 1909 he has been engaged in general practice as a consulting engineer, the firm name being Noble and Woodard. Probably the most important work dealt with was in relation to the dry docks built for the United States Government near Honolulu. He was also for a time consulting engineer to the Quebec Bridge Board, also consulting engineer for the Board of Water Supply, New York City, and for the Public Service Commission of the First District of the State of New York.

He was a past-president of the Western Society of Engineers, the American Society of Civil Engineers, and the American Institute of Consulting Engineers. He was elected to the Council of this Society in 1912 and had served several years on the Library Committee.

In 1910 he was awarded the John Fritz Medal for notable achievements as a civil engineer, and in the same year was elected an honorary member of the Institution of Civil Engineers of Great Britain, a distinction which no other American has had. In 1912 he received the Elliott-Cresson Medal of the Franklin Institute in recognition of his distinguished achievements in the field of civil engineering.

Mr. Noble was deeply interested in anything effecting the status of the engineering profession. His unfailing good humor, his kindliness and sweetness of disposition, his sound common sense and good judgment, his youthful mentality, his quick and very sure perception, and his modesty, invariably impressed his colleagues with whom he worked on many committees, and commissions in which he was so active.

He possessed a combination of strength, gentleness, tact and discernment rarely met with. He was universally respected by all who had any business dealings with him. The plain workman, the man with the pick and shovel, the contractor under him, the highly trained technical engineer, or the president of a great corporation, all appreciated the nobility, simplicity, and rugged honesty of his character. His personality was such as to evoke the faithful and enthusiastic loyalty of his subordinates, and the deep, strong, and lasting affection of all those who were honored with his friendship.

At the funeral services on the evening of April 21, the Society was represented by Jesse M. Smith, Past-President and member of the Council; Leonard Waldo, Chairman, and E. G. Spilsbury of the Library Committee, Charles Whiting Baker, Rudolph Hering, J. Waldo Smith, C. M. Wales, W. L. Saunders, and Calvin W. Rice, Secretary. E. W. S.

EDWARD PUCHTA

Edward Puchta was born October 15, 1870, in Washington, Mo., and received his education in the public schools and at Washington University, from which he was graduated with the degree of M.E. in 1892. In 1894 he entered the service of the Western Electric Company in Chicago as draftsman. From 1897 to 1899 he was employed by the Diesel Motor Company of America, as assistant engineer, under the supervision of Col. E. D. Meier, spending the first four months of his time abroad supervising the construction of engines being made for them in Germany.

In 1899 he returned to the Western Electric Company as chief draftsman, becoming in 1901 assistant superintendent of the Chicago shops. He held this

position until 1913, when he was appointed assistant superintendent in charge of the employment and welfare work for the Hawthorne works of that company, continuing in this work until the time of his death on February 25, 1914.

MEETINGS

CINCINNATI MEETING, APRIL 14

The members of the Cincinnati Section were the guests of the University of Cincinnati Student Branch on the evening of April 14, in the auditorium of the University. K. C. Grant gave an illustrated lecture on the Flood Prevention Work in the Great Miami Valley, a subject of considerable local interest. The flood of March 1913 caused great loss of life and property, and the dam and reservoir systems now under consideration for the prevention of future floods were explained in detail to an interested audience.

BOSTON MEETING, APRIL 8

At the meeting held in the Assembly Hall of the Engineers Club, Boston, April 8, W. O. Hildreth of the Lamson Company gave an illustrated paper on Selective Types of Conveyors. These are conveyors adapted for delivering packages or other materials from a central station, or from intermediate stations, to various other stations as selected by the sender at the time the goods are despatched. This paper and illustrations showed the practice in department stores, postoffices and industrial plants.

F. B. Williams of the same company presented a paper on Pneumatic Conveyors and illustrated particularly the tube systems for transporting mail, for long distances underground. The government specification requires a speed of 30 miles per hour for this service. He also showed numerous illustrations showing the cash systems in department stores.

S. L. Haines of the Link-Belt Company showed some slides illustrating the latest developments in the line, especially belt conveyors in use for handling large quantities of magazines and weeklies. He also showed several types of link-belt elevators for packages.

The meeting was well attended; a general discussion of the papers followed their presentation.

MEETINGS IN BUFFALO

H. M. Wilson, engineer in charge of the U. S. Bureau of Mines Experimental Station, gave an address at the meeting of the engineers of Buffalo, N. Y., on March 26, 1914, at which about 100 were present. Mr. Wilson chose as his subject, Mine Safety and Mine Rescue Work, and gave many interesting facts regarding dust and gas explosions. The lecture was illustrated by lantern slides and moving pictures.

On April 10, Prof. L. P. Breckenridge of Yale University lectured before the engineers on Industrial Germany, giving the impressions gained by him on his several visits. The workman of Germany, he said, is industrious, thrifty, patient, thorough, contented. In the last ten years no country has grown so fast industrially, and America is being forced more and more to meet German competition. Trade schools are widespread so that labor is trained. The German is apt to lack organization and direction in his industrial efforts, however, and for this reason more than 150 American managers have been taken to Germany to direct the industries.

MILWAUKEE MEETING, FEBRUARY 3

At a meeting of the Society in Milwaukee on February 3, Percy C. Day gave a talk on Wuest Herringbone Gears, giving an abstract of his paper on the same subject published in the Transactions, Volume 33. Lantern slides were used to illustrate his remarks.

NEW YORK, APRIL 14

At the monthly meeting of the Society in New York for April, Willard C. Brinton delivered an address on the subject of Graphic Statistics for the Engineer and the Executive. In his talk, which was illustrated with lantern slides, he described some of the graphic methods not generally used by engineers, but which could be of very great assistance to men who must frequently condense and abstract information and write reports. He showed that some of the comparative methods and graphical records now in use by the biologist and statistician could be quite generally applied to the work of the engineer if more widely understood. Most of the speaker's talk was a discussion of methods for keeping corporation operating records in convenient form for instantaneous reference by executive officers. This phase of the subject attracted a great deal of interest and some interesting discussion followed.

These irregular or jerking motions of the governor, as one may be inclined to assume from their periodical occurrences, may be rather ascribed to forces acting intermittently, and caused by the play in the wheels of the governor and actuating gear shaft drives and back pressure exerted by the steering gear drive on the governor. These periodically recurring variations in the adjusting gear can affect either favorably or unfavorably the regularity of the governor during one governor operation. The following methods were used to determine the influence of the separate action of each of these elements during the normal operation of the experimental engine: In order to determine the influence of the governor drive on the sleeve motion, the steering gear was held rigid while the governor was allowed perfect freedom of motion. On the other hand, to determine the influence of the return back pressure of the steering gear, the governor was held rigid while the steering gear was given freedom of motion. The diagram of the sleeve motion, Fig. E_c, with the steering gear held rigid, shows a certain regularity of action which may be seen in the fact that after each 11 turns of the crank, there occur equal periods of oscillation, evidently due to the ratio of transmission of the governor drive being 15 to 11, while the same pressure in the teeth occurs after each 11 revolutions of the steering gear shaft. It appears, therefore, that the oscillation phenomena connected with the steering gear drive shaft and governor spindle are caused only by the inexactness of the cut of teeth or wedging of gear wheels, since otherwise, that is, with an absolutely uniform gearing, the periodically occurring difference in the transmission of motion would not take place. As far as the work of adjustment is concerned, it does not appear to be affected by the frictional resistance of the governor and its adjusting gear, but its degree of irregularity is correspondingly reduced and depends only on the resistance to adjustment of the steering gear, if the mass action of the governor be considered as having constant influence. The back action of the steering gear obtained with the governor held rigid and steering gear free, as shown in the curve (Fig. E_b), appears to be of secondary importance as compared with the influence of the governor drive. It soon produces very slight (though regularly occurring with each revolution) jerkings which cause a temporary sluggishness in the adjusting motion. Fig. F represents the variations in electric potential and current, speed of rotation, sleeve motion and tension in the governing rod which occur when the load on the engine is suddenly reduced from 42 to 12.6 kw. The mutual relations between the amount of power put in at the steam end and that taken out electrically, as well as the variations in velocity during the process of reduction of load are shown in the diagrams of Fig. G, where the steam output is determined from indicator diagrams. In considering the curves of the governor process shown in Fig. G, of first importance is the mutual variation of the average steam output and electrical resistance during the crank revolutions which follow one another. In this diagram, the loss of the steam engine and dynamo are subtracted from the ordinates of the curve N_i which shows the indicated output; the curve N_e is thus obtained representing the effective or useful steam output required for the generation of the electrical output N_{e1}. Since during the process of load alterations the two amounts of output do not coincide, sometimes the steam output and sometimes the electrical output predominating, the amounts of excessive power which are shown by the sectioned areas must be either taken up or given out by the flywheel masses, a process which determines the magnitude and kind of the average speed alterations as indicated in the lower curve in Fig. F. The two output curves N_e and N_{e1} characterize to a certain extent the process of variation of the work put in and taken out, the difference in which causes the variations in speed during the change in load, while equalization can occur only when a new state of normal operation is established. Side by side with these variations in speed which determine the degree of sensitiveness ϵ_r of the governor, and disappear after a certain small or large number of crank revolution, there are also variations in velocity which are caused by the variations of tangential forces acting on the crank and which determine the degree of irregularity δ_s of the crank shaft and flywheel, and which appear as continually occurring variations of the peripheral velocity under all conditions of operation. As regards further the steam and electrical output during the process of regulation, one may state that within the limits of the degree of irregularity of the governor δ_r the variation of useful steam output may be directly determined from the curve of the sleeve lift and of the speed, while the variation in the electrical output with the system of loading such as represented here may be determined directly from the velocity curve.

Machine Shop

On Heat Process Occurring in Cutting Metals, and Best Speeds of Cutting (*Über die Wärmevorgänge beim Spanschneiden und die vorteilhaften Schnittgeschwindigkeiten,* H. Friedrich. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, nos. 10,.11, 12, pp. 379, 417, 454, March 7, 14, 21, 1914. 14 pp., 22 figs. *etA*). The present investigation was proposed to cover the heat phenomena in cutting metals and their relation to the most advantageous speed of cutting. The investigation was started partly along theoretical lines and partly practical. The theoretical part covered (*a*) the derivation of an equation expressing the most advantageous speed of cutting from its functional relation to the heat distribution in the metal cut and the tool used; (*b*) the derivation of the equation for the most advantageous speed of cutting on the basis of the temperature of the shaving, and (*c*) the comparison of similar heat processes. The practical part of the investigation covers tests for the determination of the constants of materials, as well as brake tests and tests of high-speed lathe with multistage gear drive tests, cutting speed, and the testing of the material used; further, heat determinations at equal cross-section of shaving and variable speed of cutting, and at a normal speed of cutting and variable cross-section of shaving.

The importance of the heat process in the cutting of metals did not become really serious until the introduction of high-speed steel. In the cut of metals, one may distinguish the action of the tool and of the piece cut and the motion phenomena in the material cut, the resistance occurring thereby, the power used, and the heat process. The first and second classes of phenomena have been sufficiently investigated while the pressure used for cutting a shaving of certain dimensions and the heat developed therein have not yet been sufficiently investigated. The action of the tool on the piece of metal machined consists in upsetting, bending and cutting of the material of the shaving. The stresses in the material which take place during these processes are

therefore comprised of compression bending and shear stresses. In addition, there is the wedge action of the tool, the friction of the cutting edge, back edge and breast part of the steel which depends on whether the cutting edge must press into the material or whether the shaving breaks off from the metal piece before it comes in contact with the cutting edge of the tool. Since it is impossible to treat theoretically the resistance to cutting, under the consideration of all these influences, one has assumed hitherto that the specific resistance to cutting for a given material is invariable, which is, however, untrue as shown by experiments of recent date. This makes it necessary to investigate the power used in cutting the shaving in connection with the heat processes occurring thereby.

In experiments on resistance to cutting it was found that the cutting pressure per unit surface of the cross-section of the shaving is not invariable and that it becomes smaller when the cross-section of the shaving becomes larger, or that the consumption of power for a given amount of shaving is smaller when the shavings are thick than when they are fine. This might be derived also from the following consideration. If a piece of metal is to be cut into small shavings, and another piece is to be cut first into thick shavings and then into fine ones, in the first case there is only the labor of cutting, while in the second case there is both that of cutting and of splitting, and one may therefore assume that for an equal amount of shavings the work of cutting is not the same in the case of fine or thick shavings. The specific pressures of cutting can therefore also not remain constant. The work of cutting per unit quantity of shavings is the larger the greater the area of surface cut off, or the surface produced by splitting. If the work of cutting is divided into work of friction and that of changing the form of the material, the second increases with the cross-section of shavings and the first with the area of the surface of shavings. The assumption that the total work is proportional to the surface is therefore confirmed by experimental data. One can therefore consider the resistance to cutting P in accordance with the equation

$$P = kf + w\beta$$

as consisting of two parts of which the first is proportional to the cross-section of the shaving f and the second to the surface of the shaving β, while coefficient k represents the strength of material and w is a function of the friction of the surface of cutting. In cutting strong or hard materials such as metals, the resistance of the metal is of prime importance, while in handling soft stuffs, such as leather, the total resistance is mainly a function of the resistance in the surface of the cut.

The speed of cut could be raised as high as desired if it had not been proved by circumstances that at too high velocities of cut the cutting edge becomes dull owing to excessive heat. The physical condition for the most advantageous speed of cutting may therefore be expressed as follows: *The temperature of the cutting edge must not exceed a certain definite value.* There are several circumstances which determine when this maximum admissible temperature is reached, and that depends on the amount of heat generated in cutting the metal, the distribution of the heat and the rise of temperature produced thereby. The amount of heat generated in cutting is a function of the work of changing the form of the material cut and the work of friction at the cut. The heat is therefore liberated inside the shaving and at the surface of the shaving, and the amount liberated in a given period of time is proportional to the work of cutting consumed in that time. The distribution of heat starts from the place of cut at which the heat generated may be considered as heat freely liberated and is distributed through the shaving, the tool, the piece machined and the surrounding medium. The rise of temperature is at its maximum at this place of cut. At the beginning of the cutting this rise of temperature is fairly rapid, but after a certain time it reaches a certain normal state if the speed of cutting, resistance to cutting and other variables remain constant. The temperature at the place of cut is, therefore, what under given conditions determines the admissible speed of cut, but it cannot be determined by direct measurement and, therefore, the permissible speed of cutting is later on in this investigation expressed in a different manner than as a function of the rise of temperature.

At the basis of the present investigation and the heat measurements were laid certain physical considerations. On the basis of the distribution of the heat generated in cutting and shaving, an equation has been derived for the most advantageous speed of cutting, this equation being in accord with another equation derived from the consideration of the work consumed in cutting. At the velocities of cut determined in accordance with this equation, the rise of temperature of the shavings for various cross-section of shavings is accepted to be approximately constant, which is explained through the processes of heat distribution and has been confirmed by experiments. Further, an equation has been derived, and found to be true by experiments, expressing the variations of temperatures of shavings at constant cross-section of shavings and at various places of cut. Owing to the variable heat conduction which takes place with various forms and formations of shavings, as well as owing to the variations in the specific heat and coefficient of heat conductivity of various materials, the equation derived for this case can be considered as being only approximately correct. But it has been found that it gives values in fairly good accord for practical processes with values obtained experimentally.

The author closes with the following important conclusions: The rise of temperature for shavings of equal cross-section, but different speeds of cutting, increases with the speed of cutting, since at the slower speed of cutting the unit of the surface of the shaving is enabled to give off more heat to the surrounding medium. The variation of the rise of temperature with varying speed of cutting is expressed by means of a special equation, determined from the heat given off to the surrounding medium and that taken up by the shavings, and experimental results have confirmed the correctness of the conclusion. In order to avoid excessive heating of the tool, the temperature of the shaving at various cross-sections of the shaving and at various speeds of cutting must not exceed a certain value. As a condition for constant temperature of shaving may be conceded the conduction of equal amounts of heat per unit of time and per unit of area of the shaving surface. In this way two equations are obtained, one for the work used in cutting, and the other for the distribution of heat in the shaving, from which the corresponding speeds of shaving may be calculated. Experiments have shown that the speeds of cutting determined

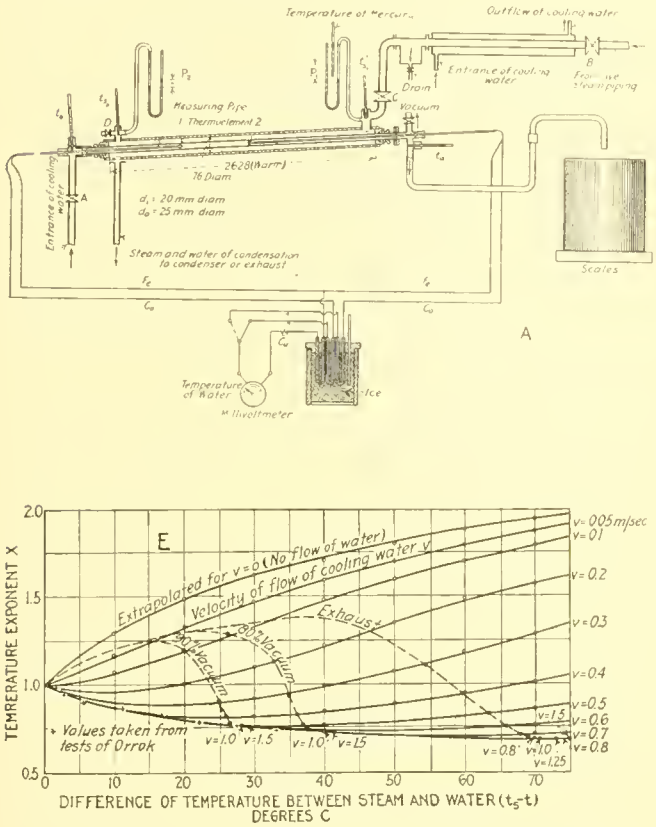
in this manner produce constant temperatures of shaving. The efficiency of the lathe increases rapidly with increased cross-section of shaving. It acquires its maximum with such metals as were used in these tests when the cross-section of shaving is from 2 to 4 qmm., and for larger sections of shaving remains nearly constant. When the largest and smallest ratios of gear transmission are used, the efficiency is somewhat lower than with the average gear transmission. It is better to avoid shavings of less than 1 qmm. cross-section.

Steam Engineering

Tests on Heat Transmission from Steam to Cooling Water (*Versuche über die Wärmeübertragung von Dampf an Kühlwasser,* K. Hoefer. *Zeits. für das gesamte Turbinenwesen,* vol. 11, no. 8, p. 113, March 20, 1914, 3 pp., 10 figs. *etA*). The article describes extensive tests made in the mechanical laboratory of the Technical High School of Berlin on heat transmission from steam to cooling water. The complete account of the tests was published in *Mitteilungen aus dem Maschinen-Laboratorium der Kgl. Technischen Hochschule zu Berlin,* Vol. 5. The main purpose of the tests was to establish the manner in which the amount of heat transmitted from steam to water in cooling pipes depends on the difference in temperatures of these two media. It is usually assumed that the amount of heat transmitted is directly proportional to the difference in temperatures, while there are also indications that it may vary as the square of the difference in temperatures. On the other hand, Mr. Orrok in his paper on The Transmission of Heat in Surface Condensation, published in *Transactions, Am. Soc. M. E.,* Volume 32, Page 1139, has found from extensive experiments that the amount of heat transmission is

$$dW = c\,dF\,(t_s - t)^{x}$$

where dW is the heat transmitted over surface dF, while t_s and t are the temperatures of steam and water respectively, c being a constant. The present tests had for their purpose, the elimination of these contradictions and the establishment of the temperature exponents for various conditions. Fig. A shows the experimental arrangement used. The water flows through a brass pipe having an inside diameter of 20 mm. (0.8 in.) and an outside diameter of 25 m. (1 in.) with a length of 2628 mm. (104.4 in.) and was heated on the outside by steam. Particular care was taken that a uniform stream of steam should be present along the entire length of the pipe so as to prevent stagnation of air. The temperature of the water in the pipe was measured by two displaceable iron-constantan thermo-elements, the voltage of these thermo-elements being measured by a very sensitive voltmeter, which permitted estimates to $^1/_{10}$ deg. cent. Since, in the same cross-section, the temperature of the water at the center was lower than that nearer the edges, in the determination of the average temperature in the cross-section a special device was used to produce eddies near the soldered place of the thermo-elements. Three series of tests were made at atmospheric pressure, and with vacuums of approximately 80 and 90 per cent. In the first two series of tests the velocity of flow of water was raised by small stages from 0.05 to 1.9 m/sec. (1.96 to 74 in./sec.) and in the test with 90 per cent vacuum from approximately 0.3 to approximately 1.5 m./sec. (11.8 to 59 in./sec.). Figs. B and C show the temperature curves which would have been obtained had the transmission of the heat been proportional to the difference in temperature and it can be seen at a



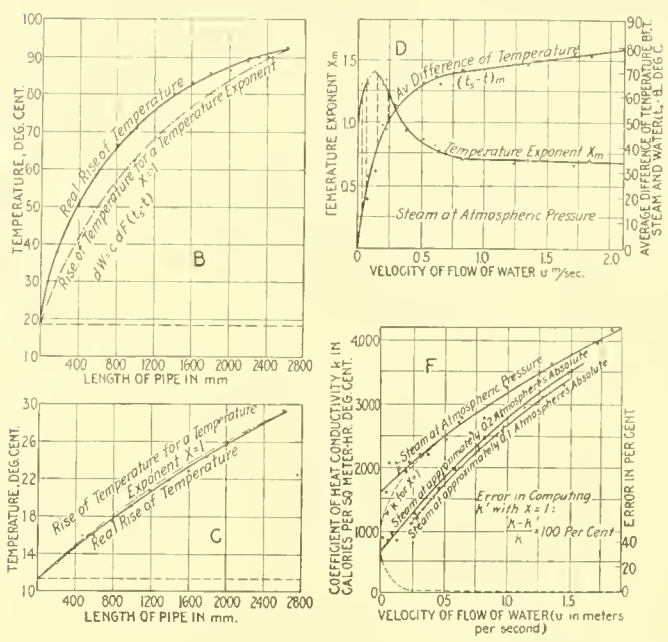


Fig. 5 Heat Transmission from Steam to Cooling Water

A Experimental Arrangement; *B* and *C* Temperature Curves for Transmission of Heat assumed to be Proportional to Difference in Temperature; *D* Average Temperature Exponent as a Function of the Velocity of Flow of Water; *E* Temperature Exponents for all Velocities of Flow of Water and Differences in Temperature; *F* Coefficients of Heat Transmission Actual and Assumed (for $x = 1$) compared.

glance from a comparison of these curves with those obtained experimentally that there is no such proportionality and that the temperature exponent is, therefore, not equal to 1. In the test represented by Fig. B the exponent must be larger than 1; in the test represented by Fig. C it must be smaller. By means of a graphical logarithmic process the average temperature exponent x_m has been determined for each test and Fig. D shows this average exponent as a function of the velocity of flow of water for the three series of tests. It is evident that the temperature exponent is not constant and that it varies both with the velocity of flow of water and with the difference between the temperature of steam and water. In order to separate the influences of these two factors, a simple graphical process was again used and Fig. E shows the temperature exponents x for all velocities of flow of water and differences in temperatures between water and steam. The important result thus shown is that *the exponent varies within wide limits,* viz., *from 0.7 to 1.9 for a difference in temperatures of 70 deg. cent.* (*126 deg. fahr.*) All the curves for $t_s - t = 0$ coincide at certain point $x = 1$. The particles of water which flow along the walls of the pipe have a temperature which is only very little different from the temperature of the pipe walls; the closer the difference in temperatures approaches the value zero (and it appears probable that $t_s - t$ at the pipe wall is very near the value zero), the closer x approaches the value one. From this it follows that the *heat transmission from the pipe wall to the outermost layers of the cooling water is proportional to the difference in temperature for all velocities of flow of water.* The fact that the temperature exponent, as referred to average water temperature, may have as different values as are shown by the experiments is doubtless due to the fact that the distribution of temperatures in a given cross-section may be very different in various cases. Just how this distribution of temperatures occurs numerically cannot be established from the present experiments, but it has been established that there are differences in temperatures at various points of the same cross-section of water in a cooling pipe. At lower velocities convection phenomena may also play a certain part, and, since the distribution of temperatures is the cause of the difference in the values of the exponents, it appears probable that the diameter of the pipe has also a certain influence on the value of the exponent.

The results of this test are to a certain extent not in agreement with the results obtained by Mr. Orrok, who found that the temperature exponent was independent of the differences in temperatures, and for all velocities of flow of water from 0.6 to about 2.6 m/sec. has a value of $x = 7/8$. On the other hand, the data obtained by Mr. Orrok confirm and add to these tests as they have been made for small differences in temperature and high velocities of flow of water.

Further, the present tests have permitted the determination of the coefficient of heat transmission k. Fig. F shows its values as a function of the velocity of flow of water v. In order to show the amount of deviation if the coefficients of heat transmission were calculated under the assumption that the temperature exponent has a constant value $x = 1$, a curve was plotted in Fig. F. For velocities of flow of approximately 0.4 m/sec. (15.7 in/sec.) the two curves coincide, since in this case x is actually equal to 1, and even for larger velocities of flow of water, there is practically no difference between the two curves. This fact is very important for the calculation of condensers, since it enables one to use the simple formula made possible by assuming that $x = 1$, namely

$$F = \frac{Q}{k} \ln \frac{t_s - t_e}{t_s - t_a}$$

where F is the cooling surface of the condenser in *qm*, Q is the amount of cooling water per hour in *kg*, t_e is the entering temperature of cooling water and t_a the temperature of cooling water flowing out. Only in the case of very low velocities of flow of water the actual conditions must be taken into consideration and the more exact formula used. For atmospheric pressures the value of the coefficient of heat transmission may be expressed as

$$k = 1600 + 1743.v^{0.82}$$

and for a vacuum of 80 per cent

$$k' = 650 + 2090.v^{0.82}$$

The exponents of v agree with each other fully and lie between 0.72 and 0.91 (as *Zoennecken* has found in his tests) and therefore ought to be very near their actual values. The difference between k and k' is doubtless due to the decrease of the coefficient of heat transmission from the steam to the wall, when the density of the steam decreases. Numerically these values cannot yet be given since the functional relation between heat transmission and density of steam is unknown.

Co-Working of Steam Boilers Running on Different Pressures (*Das Zusammenarbeiten von Dampfkesseln verschiedener Spannung. Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 37, no. 11, p. 129, March 13, 1914. 3 pp., 6 figs. *d*). At the 43d meeting of the delegates and engineers of the International Association of Boiler Inspection Societies, which took place in Moscow, Werthwein of Barmen presented a report on the simultaneous working of boilers working with different pressures. The general development of power plants requires the application of higher and higher steam pressures, at the same time as the installation of new boiler units. As a result, especially in plants which are not new, it often happens that side by side with the new boiler group working with high pressures there are also in operation a number of the older boiler units of lower pressures. The steam of the latter is in such cases used mainly for heating, cooking, preheating of water and other purposes where high pressure is not desirable or is not of material advantage. The size of the new boiler elements of large pressure is in most cases designed in a manner such that there shall be sufficient steam not only for all available power purposes, but also to a certain extent for those demands which are primarily satisfied by the older units, and the devices which insure the collaboration of the two kinds of boilers must be arranged in a manner such that on one hand all the advantages of the high pressure and available heating surface of the high-pressure boilers shall be thoroughly utilized, while on the other hand all danger for the low-pressure boilers shall be eliminated. As far as the author is aware, there is only in Germany legislative rules governing such cases of running together boiler groups of various pressures.

The Prussian regulations of 1902 were as follows: (*a*) The steam piping from high-pressure boilers must be provided with automatically acting devices (such as reducing valves, pressure regulators, etc.) by means of which

steam flowing into the collector piping shall be reduced to the lower pressure level of the other boilers. (*b*) In front of this pressure reducing device, that is, on the side of the high-pressure boiler, there shall be a cut-off valve, if possible, such as can be operated from the floor level. (*c*) The common piping shall be provided with a small scale manometer and such number of safety valves as will maintain the pressure prevailing in the piping not in excess of that prevailing in the low-pressure boiler connected thereto. (*d*) Each of the steam boilers connected to the common piping must be provided with a slow-acting long-stroke safety valve. (*e*) Each boiler must be arranged so that it will cut off from the piping. (*f*) The feed piping of boilers of various pressures connected to a common steam piping must be kept separate.

These rules have been somewhat modified by the German law for land steam boilers of 1909 and at the present time only the first section of the above regulations is in force. Both groups, high and low pressures, will give off their steam into a common piping. In the pipe connections from the low-pressure boilers to the common piping, pipe isolating valves are installed in a manner such that the cones of the valves shall be lifted by the steam flowing from the low-pressure boiler toward the collector piping. The pressure in the collector piping must therefore be somewhat lower than that in the low-pressure boiler connected thereto and the pressure of the steam acting from the high-pressure boiler must have been correspondingly reduced by means of reducing valves or in some other manner. As regards the pipe isolating valves, the most simple construction was preferred at first, such as valves with loose ball. It was soon evident, however, that in several respects these valves were unsuitable, especially where the steam engines received their steam from the collector piping and also where only the high-pressure boilers supplied steam to the engines, while the steam from the collector piping was used for other industrial purposes, such as heating or cooking. In all such cases the pipe isolating valves produced a noise due to the valve ball striking against its setting, until finally the constant strokes destroyed both the seat and the ball, while the noise was so unpleasant for the boiler attendant that the ball was often removed and the valve became absolutely useless. To avoid these inconveniences, it was proposed to insert into the steam piping special steam collectors and to use pipe isolating valves of such a construction as to avoid the production of the noise.

Schaffer and Budenburg in Magdeburg used the pipe isolating valve shown in Fig. 6A, with the horizontal axis coming out from the casing through a stuffing box. To the stuffing box end of the axis is fixed a lever having on one end a tension spring and on the other end an oil brake. If variations of pressure occur in the piping the valve cannot fall off, owing to the damping action of the spring and brake. In many cases the spring alone, without the brake, is quite sufficient. Dreyer, Rosenkranz and Droop in Hannover have placed on the market a pipe isolating valve shown in Fig. B, with the valve cone suspended on a spring and therefore sitting much lighter than an unbalanced cone. Although a valve of this type has been placed on a collector piping from which steam was supplied to a rolling mill engine and a steam hammer, no knocking in the valve has been observed. Franz Seiffert and Co. in Berlin used a pipe isolating valve (Fig. C) where the valve cone is connected with a balanced brake piston.

All these valves have succeeded in eliminating most of the troubles occurring with the ordinary type pipe isolating valve, but in order to make possible the working of two boilers of various pressures on the same collector piping, without any undesirable occurrences and with full safety for the low-pressure boiler, additional devices have to be installed, and the above mentioned Prussian regulations indicate what these devices should be.

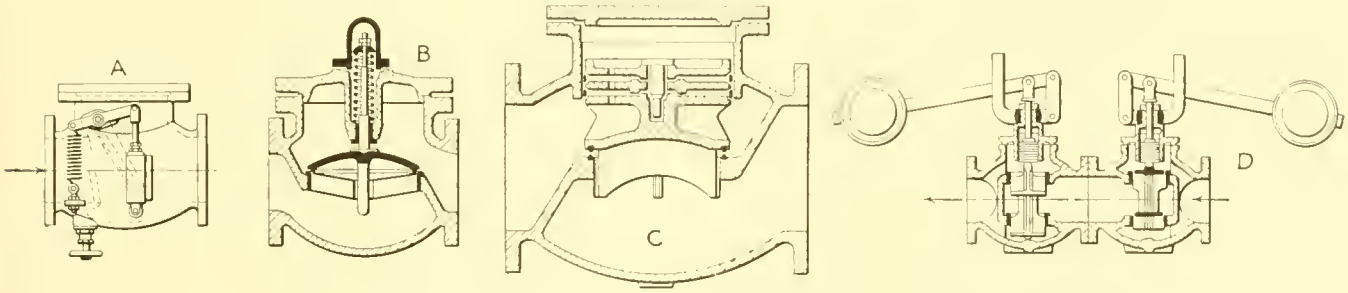


Fig. 6 Pipe-Isolating and Pressure-Reducing Valves

In the first place the steam piping running from the high-pressure boiler to the common pipe must be provided with a pressure-reducing valve by means of which the high pressure of the steam shall be reduced to the lower level and since, as a rule, these pressure-reducing valves cannot be used as stop valves, separate valves of the latter kind have to be installed, in a manner such that they can be safely and easily handled from an accessible place (best from the fireman's side of the boiler). When it is desired to maintain the steam pressure in the high-pressure boilers as uniform as possible and to let into the common piping only the excess of steam, it is advisable to employ mechanically acting devices rather than to rely on the regulation by boiler attendants. This can be done by a so-called overflow valve connected with the pressure reducing valve, one type of which (built by Schaffer and Budenberg) is shown in Fig. D. The overflow valve opens first and lets out the steam as soon as the pressure in the high-pressure boilers has reached a predetermined value, while the pressure reducing valve delivers high-pressure steam to the collector piping as soon as the pressure of the steam in that latter pipe has reached the level of the pressure in the low-pressure boilers supplying steam to the same piping. The article describes also an overflow and pressure reducing valve of Hübner and Mayer in Vienna, said to have given complete satisfaction in actual practice.

Smoke Catchers for Use in Roundhouses (*Über Rauchfänger für Lokomotivschuppen,* Gwosdz. *Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 37, no. 12, p. 144, March 20, 1914. 3½ pp., 21 figs. *d*). The article describes a number of older types in German practice. In most of these the smokestack valve used to be closed automatically as soon as the smoke catcher funnel was raised, but arrangements might have been made to keep it in any position desired, since the funnel was low down. Further, in these older constructions, an automatic arrangement was provided for placing in the open position the throttling valve when the catch funnel was lowered down. The Prussian railway administration, in 1907, however, found that if the throttling valve on the smoke catcher was fully open there was powerful ventilation over the locomotive, and the latter, especially if it was to go out of service, was cooled down very rapidly. This sometimes produced leaks in the tubes. Therefore an order was issued that no smoke catchers should be used where the throttling valve was automatically opened.

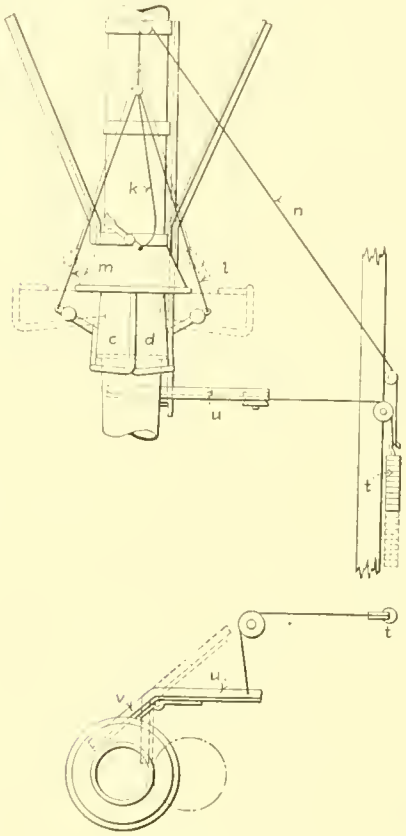


Fig. 7 Fabel Roundhouse Smoke Catcher

The article accordingly describes a number of apparatus complying with these requirements. The endeavor to make the connection between the locomotive stack and the smoke catcher pipe as close as possible led to the evolution of a special type of smoke catcher, with a divided jointing funnel.

Fig. 7 represents the Fabel apparatus constructed on this principle. The funnel consists of two nearly cylindrical clappets, *c* and *d*, which are movably located by journals and eyes on the smoke pipe and, when inclined, enclose the locomotive smokestack. By means of ropes *l* and *m*, operated by a common wire *n*, they can be placed in the position indicated by dotted lines, and the rope *k* connected with the wire *n* serves to adjust the smoke pipe clappet valve. The latter arrangement has been tested in accordance with the regulations of 1907. The disadvantage of this arrangement lies in the fact that the locomotives must stand almost exactly under the smoke pipe, since otherwise the smokestack would not be tightly enclosed by the clappets. To avoid this and also to make the catcher work with a locomotive having various heights of smokestack, the designer placed between the funnel valve and the smoke pipe an adjustable pipe extension.

Explosions in Water Tube Boilers with Headers (*Explosionen in Wasserrohrkammerkesseln,* Bracht. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, no. 9, p. 344, February 28, 1914. 2pp., *gp.* Paper read before the Lower Rhine Section of the V. d. I.). When watertube boilers were first introduced one of the main arguments in their favor was conceded to be their freedom from explosion danger, and on this account special regulations had been instituted in Germany permitting the use of watertube boilers under conditions where ordinary types of boilers were not allowed. Later, however ,several explosions of watertube boilers occurred which tended to show that this type was not so safe as supposed.

The first explosion of this kind took place in June 1912, in the boiler room of the electrical central station of the Phoenix Rolling Mills at Lerenfeld, Germany. In that plant were four boilers, three of which were made by one concern and the fourth installed in 1910 by another concern. It was this last that exploded. Its rated working pressure was 15 atmospheres, but as the other three boilers were allowed to work with only 13 atmospheres, the same pressure was maintained in the fourth boiler. The heating surface was 412 qm. and the chain grate 14.4 qm. The water headers had a width of 6 m. or 6.080 m. and were made in one piece with arches for the two boiler drums. The width of the frame was 254 mm. and the header 200 mm., the thickness of the header plates being 18 mm. The explosion may be referred back to the fact that a circulation plate in the front part of the header, which was welded in, was entirely torn away, and through the opening that formed, the water content of the boiler rushed out, while the upper part of the boiler broke away from the foundations and pipe connections, broke to pieces and was thrown 50 m. from its original place, causing considerable damage on the way. Bricks and iron pieces flew in all directions for a considerable distance. Two firemen were killed and a third died soon after. One person was seriously injured and six persons less seriously.

The second case of explosion of a watertube boiler took place in November 1912, at the iron works of Menden and Schwerte in Schwerte. Three persons were killed and two seriously wounded. The boiler was installed in 1911 to work at a pressure of 13 atmospheres gage. The heating surface was 300 qm. (3210 sq. ft.), the grate area for hand-firing, 8 qm. (85.6 sq. ft.). The boiler worked in connection with three other boilers of the same size and construction. The explosion was practically a reproduction of the Düsseldorf case. Here also without any previous warning the circulation plate of the header broke off, but remained hanging, since at the corners it had no welds. The opening

which was formed had a cross-section of about 1 qm. (10.7 sq. ft.) through which suddenly water and steam were offered a free passage. The boiler was thrown backwards to a distance of 58 meters (say 185 ft.) in the direction of its longitudinal axis, totally destroying its setting and partly destroying the other boilers, as well as greatly damaging other property.

In November 1912, occurred a third explosion, this time at the plant of the Deutscher Kaiser, at the rolling mill Dinslaken. The boiler had a heating surface of 157 qm. and 12 atmospheres gage pressure and was built in 1897. It has worked since that time with few interruptions, day and night, using the waste heat of two milling furnaces. On the day of the explosion, the boiler which had for some time been out of commission, owing to repairs on the furnaces, was to be again heated up. When the pressure reached approximately 9½ atmospheres, the explosion occurred. The boiler had not yet been connected with the steam piping. Shortly before that a noise had been heard which was falsely supposed to be due to steam escaping from the safety valve. The boiler attendant was thrown some distance and died several hours later. The boiler itself was thrown to a distance of about 6 m. (say 20 ft.). The inspection of the boiler showed that the manhole of the rear header was separated and the staybolts from the circulation plate along the welded seam broken, and that the header was drawn upwards to where it found less resistance offered by the tubes back of the superheater. The nine staybolts in the lowest row have been torn off from the tube wall, while the other seven have been torn out of the manhole wall. In the second row from below there were nine staybolts torn out from the manhole wall. The circulation plate was not deformed. As regards the nine staybolts torn out from the manhole wall, it appears that six of them were broken previous to the explosion while the other three indicated a somewhat more recent fracture.

At first it was supposed that these explosions were caused by defective work, an opinion which was at first endorsed in full by experts and even by the representatives of the manufacturers. The circulation plate was butt-welded toward the header plates and the hammer blows of the welder, which could of course have been applied only from the outside of the connection, probably caused the weld to take place in such a manner that the plate edges were superimposed. The connection between the metal elements was so slight that traces of old chiseling could easily be seen on the circulation plate. On the inside of the header the iron shavings which were used as a welding material have melted and flown into one piece with the walls so that there was available both a tight connection and a certain amount of strength. Test pieces have been cut from the plates and investigated and it was found that the walls were made of wrought iron, having strength of 34 to 41 kg/qmm. which could be easily welded. On the lateral circulation plate of the latter, the test pieces show a materially better weld than was the case on the bottom plate. These circumstances confirmed the assumption that in the manufacture of the bottom seam the art of welding may have been imperfectly applied and that for some reason the workmanship was at fault.

The manufacturer, however, would not accept this view, since the welder who worked on this header was an old worker, in the business for many years and has made many headers without any trouble. Therefore he insisted that the cause of the explosion be sought in some irregularity of operation, such as, for example, the possibility of the chamber (owing to a break in the arch) being exposed to the fire for a comparatively long time. In addition, there was considerable mud and boiler scale pieces collected in the lower part of the header which might have led to overheating of the seam and to a rupture of the parts. This assertion of the manufacturer was thoroughly investigated and may be considered as having some foundation in a certain sense. During the night before the explosion 30 to 40 bricks fell from the lower arch ring of the grate. This circumstance alone could not have caused over-heating. A case is on record where one-half of the fire arch broke down. In that case, however, part of the arch which broke was near the hopper, and for operative reasons the work of the boiler had to be continued for a certain time, this being done by closing the wall by a fire sheet so as to prevent a false entrance of air. In both cases, fault of attendance can therefore be left out of consideration, although it must be admitted that an overheating of the plates had taken place, as shown by blue spots in one place on the plate.

It is hardly possible to admit that the presence of mud and boiler scale inside the boiler intensified over-heating, since, water of condensation with 5 per cent supplementary water, which passed previously over a cleaner, was used as feedwater. In addition, owing to the inclined position of the header, in the lower part of the latter there was a sort of dead angle in which all the impurities present used to deposit. The speaker was therefore of the opinion that in this case also the cause of the explosion lay not in the defective workmanship of the seam but in a defective method of setting of the boiler which had not sufficiently protected the seam from overheating. In the Schwerte explosion it was found that the circulation plate and the lower part of the header wall showed blue spots, while inside the walls was found a scale deposit of 5 to 8 mm. (0.2 to 0.32 in.) thick, while the mud contained a considerable amount of oil. It appears further, that the overheating of that particular spot was also intensified by the fact that the protective setting of the header was partly broken and crumbled up. Here also, therefore, the setting had not afforded sufficient protection to the seam and the overheating finally caused its failure.

The third case in Dinslaken is materially different. Overheating did not seem to have played any material part in the accident which appears to have been brought about mainly by the failure of the staybolts, which were placed too far away from the edge (200 mm. or 8 in.) so that the seam was stressed too high.

The author discussed further the lessons which can be drawn from these explosions and the preventive measures which should be taken to avoid their repetition. The Central Association of Prussian Societies for the Inspection of Boilers has decided to carry out a series of experiments by building a number of test headers in order to test thoroughly the distribution of strength, not only in headers which have been produced by butt-welding, but also of those which have been produced by other methods without welding. These tests have not yet been completed. The author had occasion to be present at tests when all boilers had been broken by water pressures, butt-welds had broken at pressures from 50 to 60 atmospheres, the butt-welds here used being of the

same type as in the exploded boilers. This would indicate that the butt-weld, although not an ideal method of making a seam, was still strong enough to bear all regular strains. But in the operation, suitable conditions must be maintained, and if this were done, the faith in the reliability of the double header boiler might be recovered. In Germany there are now 15,000 to 20,000 of such boilers at work and giving good satisfaction, and the few cases of explosions, though certainly regrettable, ought not to prejudice against this type of boilers.

Strength of Materials and Materials of Construction

Testing Fire Bricks (*Die Prüfung feuerfester Steine*, A. Gary. *Feuerungstechnik*, vol. 2, nos. 11 and 12, pp. 178 and 199, March 1 and 15, 1914. 9 pp., 14 figs. *dp*). Prof. A. Gary, head of the great experimental station at Gross Lichterfelde West, presents in the present article a description of methods used for testing fire bricks, covering the following subjects: Chemical composition of the brick, determination of its shape, consistency, space, weight, specific weight and density, volume after repeated heating, compression and expansion, variation of length with heating, heat conductivity, melting temperature as compared with that of Seger cones, softening and change of consistency in heating and in contact with other bodies, compression strength when cold or hot, and porosity with respect to gases. The author discusses in detail the methods used and suitable apparatus for determining all these factors.

Heat Conductivity, Specific Weight and Porosity of Refractory Materials (*Wärmeleitfähigkeit, spezifisches Gewicht und Porosität feuerfester Steine*, P. Goerens. Cp. *Feuerungstechnik*, vol. 2, no. 12, p. 204, March 15, 1914. *e*). Paper presented by Prof. P. Goerens at the 34th meeting of the German Association of Manufacturers of Refractory Materials. In establishing a heat balance of metallurgical processes, under the heading "heat losses through conduction and radiation" are given values which evidently require to be corrected. This is due to lack of proper methods for determining these losses and to their determination as the difference between computed input and output of heat, so that, for example, in some of the blast-furnace heat balances the heat losses over radiation and conduction varies from 0.58 to 33.3 per cent of the total heat. These wide variations are in the first place due to the fact that practically all the errors in other observations are lumped up under the heading "heat losses through conduction and radiation."

Engineer J. W. Gilles has performed a series of experiments in the Metallurgical Institute of the Aix la Chappelle Technical High School, using bricks of normal type in order to determine directly the heat conductivity of fire brick. The apparatus consists of an electrically heated plate, by means of which the surface of the brick was heated, a calorimeter for the determination of the heat coming through, and a number of thermoelements for the determination of the distribution of temperature in the mass of the brick. In addition to the heat conductivity of the brick there were also determined its true specific weight g_w, apparent specific weight g_s and the absolute porosity P_{abs} determined from the formula

$$P_{abs} = \frac{g_w - g_s}{g_w} \times 100$$

From these data it appears that the absolute conductivity increases with the temperature in the case of fire brick, half fire brick, slate, lias, silica and carbon, but noticeably decreased in magnesite. Further, in chemically similar refractory substances, the heat conductivity decreases with porosity.

ENGINEERING SOCIETIES

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Bulletin, vol. 15, no. 163, January 1914, Chicago, Ill.

Report of Committee on Iron and Steel Structures
Report of Committee on Masonry
Report of Committee on Wood Preservation (Abstracted)
Report of Committee on Grading of Lumber

Report of Committee on Wood Preservation (54 pp., 28 figs. *eA*). The report on wood preservation discusses the use of oil from water gas and coal tar in creosote oil, and comes to the conclusion that wherever possible only grade 1 coal tar creosote should be used and under no circumstances should coal tar be added to creosote of this grade. Where it is advisable to use coal tar in mixture with the lower grades of creosote, such as grades 2 and 3 of the American Railway Engineering Association and poorer, the following precautions should be adhered to: There must be a distinct understanding between all concerned that a mixture as specified is used; the coal tar should be added to the creosote only at the plant and under the direct supervision of the railway company; under no circumstances should the coal tar constitute more than 20 per cent of the mixture. The coal tar and creosote should be thoroughly mixed at a temperature of approximately 180 deg. fahr. before being applied to the timber, the tanks containing the mixture being heated and agitated thoroughly before any oil is transferred to the working tanks. Only low carbon coal tar can be used. The amount of free carbon should not exceed 5 per cent, and in treating with the mixture, the temperature of the solution in the cylinder should be not less than 180 deg. fahr.

The article quotes records from service tests with periodical inspection of the sections of test tracks of various railroads as well as the methods of determination and valuation of various values under test. In an appendix is given an extensive discussion by Hermann von Schrenk and Alfred L. Kammerer on the use of refined coal tar in the creosoting industry in which the authors object to the view of considering coal tar additions as adulterations, and by a series of experiments come to practically the same conclusions as stated above, insisting upon the necessity of stopping the practice of selling creosote oil mixed with coal tar as No. 1 grade oil.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. 26, no. 1, February 1914, Washington, D. C.

A Method of Closing Pores on Hollow Brasses, Capt. F. W. Bartlett, U.S.N. (4 pp. *p*). On the U.S.S. Montana it was found that the six bottom brasses for the main shaft of each engine were porous, so that water from the water service mingled with the oil of the journals to a slight extent. The babbitt metal of the brasses, however, was in excellent condition and the leaks were not where the babbitt was located, but at other points of the brasses and at points where the babbitt was cut away. As it was a very expen-

These irregular or jerking motions of the governor, as one may be inclined to assume from their periodical occurrences, may be rather ascribed to forces acting intermittently, and caused by the play in the wheels of the governor and actuating gear shaft drives and back pressure exerted by the steering gear drive on the governor. These periodically recurring variations in the adjusting gear can affect either favorably or unfavorably the regularity of the governor during one governor operation. The following methods were used to determine the influence of the separate action of each of these elements during the normal operation of the experimental engine: In order to determine the influence of the governor drive on the sleeve motion, the steering gear was held rigid while the governor was allowed perfect freedom of motion. On the other hand, to determine the influence of the return back pressure of the steering gear, the governor was held rigid while the steering gear was given freedom of motion. The diagram of the sleeve motion, Fig. E_c, with the steering gear held rigid, shows a certain regularity of action which may be seen in the fact that after each 11 turns of the crank, there occur equal periods of oscillation, evidently due to the ratio of transmission of the governor drive being 15 to 11, while the same pressure in the teeth occurs after each 11 revolutions of the steering gear shaft. It appears, therefore, that the oscillation phenomena connected with the steering gear drive shaft and governor spindle are caused only by the inexactness of the cut of teeth or wedging of gear wheels, since otherwise, that is, with an absolutely uniform gearing, the periodically occurring difference in the transmission of motion would not take place. As far as the work of adjustment is concerned, it does not appear to be affected by the frictional resistance of the governor and its adjusting gear, but its degree of irregularity is correspondingly reduced and depends only on the resistance to adjustment of the steering gear, if the mass action of the governor be considered as having constant influence. The back action of the steering gear obtained with the governor held rigid and steering gear free, as shown in the curve (Fig. E_b), appears to be of secondary importance as compared with the influence of the governor drive. It soon produces very slight (though regularly occurring with each revolution) jerkings which cause a temporary sluggishness in the adjusting motion. Fig. F represents the variations in electric potential and current, speed of rotation, sleeve motion and tension in the governing rod which occur when the load on the engine is suddenly reduced from 42 to 12.6 kw. The mutual relations between the amount of power put in at the steam end and that taken out electrically, as well as the variations in velocity during the process of reduction of load are shown in the diagrams of Fig. G, where the steam output is determined from indicator diagrams. In considering the curves of the governor process shown in Fig. G, of first importance is the mutual variation of the average steam output and electrical resistance during the crank revolutions which follow one another. In this diagram, the loss of the steam engine and dynamo are subtracted from the ordinates of the curve N_i which shows the indicated output; the curve N_e is thus obtained representing the effective or useful steam output required for the generation of the electrical output N_{el}. Since during the process of load alterations the two amounts of output do not coincide, sometimes the steam output and sometimes the electrical output predominating, the amounts of excessive power which are shown by the sectioned areas must be either taken up or given out by the flywheel masses, a process which determines the magnitude and kind of the average speed alterations as indicated in the lower curve in Fig. F. The two output curves N_e and N_{el} characterize to a certain extent the process of variation of the work put in and taken out, the difference in which causes the variations in speed during the change in load, while equalization can occur only when a new state of normal operation is established. Side by side with these variations in speed which determine the degree of sensitiveness ε_r of the governor, and disappear after a certain small or large number of crank revolution, there are also variations in velocity which are caused by the variations of tangential forces acting on the crank and which determine the degree of irregularity δ_s of the crank shaft and flywheel, and which appear as continually occurring variations of the peripheral velocity under all conditions of operation. As regards further the steam and electrical output during the process of regulation, one may state that within the limits of the degree of irregularity of the governor δ_r the variation of useful steam output may be directly determined from the curve of the sleeve lift and of the speed, while the variation in the electrical output with the system of loading such as represented here may be determined directly from the velocity curve.

Machine Shop

On Heat Process Occurring in Cutting Metals, and Best Speeds of Cutting (*Über die Wärmevorgänge beim Spanschneiden und die vorteilhaften Schnittgeschwindigkeiten,* H. Friedrich. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, nos. 10, 11, 12, pp. 379, 417, 454, March 7, 14, 21, 1914. 14 pp., 22 figs. *etA*). The present investigation was proposed to cover the heat phenomena in cutting metals and their relation to the most advantageous speed of cutting. The investigation was started partly along theoretical lines and partly practical. The theoretical part covered (*a*) the derivation of an equation expressing the most advantageous speed of cutting from its functional relation to the heat distribution in the metal cut and the tool used; (*b*) the derivation of the equation for the most advantageous speed of cutting on the basis of the temperature of the shaving, and (*c*) the comparison of similar heat processes. The practical part of the investigation covers tests for the determination of the constants of materials, as well as brake tests and tests of high-speed lathe with multistage gear drive tests, cutting speed, and the testing of the material used; further, heat determinations at equal cross-section of shaving and variable speed of cutting, and at a normal speed of cutting and variable cross-section of shaving.

The importance of the heat process in the cutting of metals did not become really serious until the introduction of high-speed steel. In the cut of metals, one may distinguish the action of the tool and of the piece cut and the motion phenomena in the material cut, the resistance occurring thereby, the power used, and the heat process. The first and second classes of phenomena have been sufficiently investigated while the pressure used for cutting a shaving of certain dimensions and the heat developed therein have not yet been sufficiently investigated. The action of the tool on the piece of metal machined consists in upsetting, bending and cutting of the material of the shaving. The stresses in the material which take place during these processes are

therefore comprised of compression bending and shear stresses. In addition, there is the wedge action of the tool, the friction of the cutting edge, back edge and breast part of the steel which depends on whether the cutting edge must press into the material or whether the shaving breaks off from the metal piece before it comes in contact with the cutting edge of the tool. Since it is impossible to treat theoretically the resistance to cutting, under the consideration of all these influences, one has assumed hitherto that the specific resistance to cutting for a given material is invariable, which is, however, untrue as shown by experiments of recent date. This makes it necessary to investigate the power used in cutting the shaving in connection with the heat processes occurring thereby.

In experiments on resistance to cutting it was found that the cutting pressure per unit surface of the cross-section of the shaving is not invariable and that it becomes smaller when the cross-section of the shaving becomes larger, or that the consumption of power for a given amount of shaving is smaller when the shavings are thick than when they are fine. This might be derived also from the following consideration. If a piece of metal is to be cut into small shavings, and another piece is to be cut first into thick shavings and then into fine ones, in the first case there is only the labor of cutting, while in the second case there is both that of cutting and of splitting, and one may therefore assume that for an equal amount of shavings the work of cutting is not the same in the case of fine or thick shavings. The specific pressures of cutting can therefore also not remain constant. The work of cutting per unit quantity of shavings is the larger the greater the area of surface cut off, or the surface produced by splitting. If the work of cutting is divided into work of friction and that of changing the form of the material, the second increases with the cross-section of shavings and the first with the area of the surface of shavings. The assumption that the total work is proportional to the surface is therefore confirmed by experimental data. One can therefore consider the resistance to cutting P in accordance with the equation

$$P = kf + w\beta$$

as consisting of two parts of which the first is proportional to the cross-section of the shaving f and the second to the surface of the shaving β, while coefficient k represents the strength of material and w is a function of the friction of the surface of cutting. In cutting strong or hard materials such as metals, the resistance of the metal is of prime importance, while in handling soft stuffs, such as leather, the total resistance is mainly a function of the resistance in the surface of the cut.

The speed of cut could be raised as high as desired if it had not been proved by circumstances that at too high velocities of cut the cutting edge becomes dull owing to excessive heat. The physical condition for the most advantageous speed of cutting may therefore be expressed as follows: *The temperature of the cutting edge must not exceed a certain definite value.* There are several circumstances which determine when this maximum admissible temperature is reached, and that depends on the amount of heat generated in cutting the metal, the distribution of the heat and the rise of temperature produced thereby. The amount of heat generated in cutting is a function of the work of changing the form of the material cut and the work of friction at the cut. The heat is therefore liberated inside the shaving and at the surface of the shaving, and the amount liberated in a given period of time is proportional to the work of cutting consumed in that time. The distribution of heat starts from the place of cut at which the heat generated may be considered as heat freely liberated and is distributed through the shaving, the tool, the piece machined and the surrounding medium. The rise of temperature is at its maximum at this place of cut. At the beginning of the cutting this rise of temperature is fairly rapid, but after a certain time it reaches a certain normal state if the speed of cutting, resistance to cutting and other variables remain constant. The temperature at the place of cut is, therefore, what under given conditions determines the admissible speed of cut, but it cannot be determined by direct measurement and, therefore, the permissible speed of cutting is later on in this investigation expressed in a different manner than as a function of the rise of temperature.

At the basis of the present investigation and the heat measurements were laid certain physical considerations. On the basis of the distribution of the heat generated in cutting and shaving, an equation has been derived for the most advantageous speed of cutting, this equation being in accord with another equation derived from the consideration of the work consumed in cutting. At the velocities of cut determined in accordance with this equation, the rise of temperature of the shavings for various cross-section of shavings is accepted to be approximately constant, which is explained through the processes of heat distribution and has been confirmed by experiments. Further, an equation has been derived, and found to be true by experiments, expressing the variations of temperatures of shavings at constant cross-section of shavings and at various places of cut. Owing to the variable heat conduction which takes place with various forms and formations of shavings, as well as owing to the variations in the specific heat and coefficient of heat conductivity of various materials, the equation derived for this case can be considered as being only approximately correct. But it has been found that it gives values in fairly good accord for practical processes with values obtained experimentally.

The author closes with the following important conclusions: The rise of temperature for shavings of equal cross-section, but different speeds of cutting, increases with the speed of cutting, since at the slower speed of cutting the unit of the surface of the shaving is enabled to give off more heat to the surrounding medium. The variation of the rise of temperature with varying speed of cutting is expressed by means of a special equation, determined from the heat given off to the surrounding medium and that taken up by the shavings, and experimental results have confirmed the correctness of the conclusion. In order to avoid excessive heating of the tool, the temperature of the shaving at various cross-sections of the shaving and at various speeds of cutting must not exceed a certain value. As a condition for constant temperature of shaving may be conceded the conduction of equal amounts of heat per unit of time and per unit of area of the shaving surface. In this way two equations are obtained, one for the work used in cutting, and the other for the distribution of heat in the shaving, from which the corresponding speeds of shaving may be calculated. Experiments have shown that the speeds of cutting determined

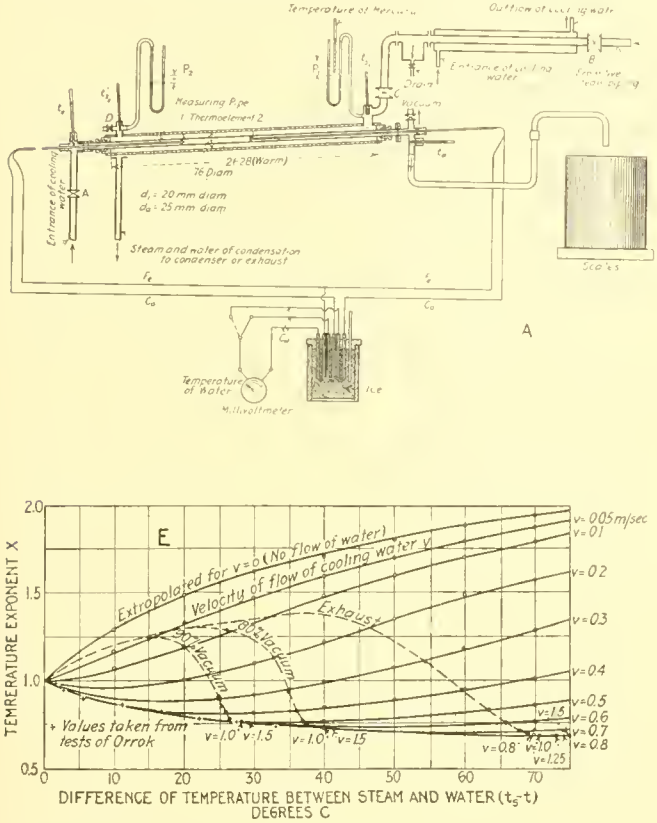
in this manner produce constant temperatures of shaving. The efficiency of the lathe increases rapidly with increased cross-section of shaving. It acquires its maximum with such metals as were used in these tests when the cross-section of shaving is from 2 to 4 qmm., and for larger sections of shaving remains nearly constant. When the largest and smallest ratios of gear transmission are used, the efficiency is somewhat lower than with the average gear transmission. It is better to avoid shavings of less than 1 qmm. cross-section.

Steam Engineering

Tests on Heat Transmission from Steam to Cooling Water (*Versuche über die Wärmeübertragung von Dampf an Kühlwasser*, K. Hoefer. *Zeits. für das gesamte Turbinenwesen*, vol. 11, no. 8, p. 113, March 20, 1914, 3 pp., 10 figs. *et A*). The article describes extensive tests made in the mechanical laboratory of the Technical High School of Berlin on heat transmission from steam to cooling water. The complete account of the tests was published in *Mitteilungen aus dem Maschinen-Laboratorium der Kgl. Technischen Hochschule zu Berlin*, Vol. 5. The main purpose of the tests was to establish the manner in which the amount of heat transmitted from steam to water in cooling pipes depends on the difference in temperatures of these two media. It is usually assumed that the amount of heat transmitted is directly proportional to the difference in temperatures, while there are also indications that it may vary as the square of the difference in temperatures. On the other hand, Mr. Orrok in his paper on The Transmission of Heat in Surface Condensation, published in *Transactions, Am. Soc. M. E.*, Volume 32, Page 1139, has found from extensive experiments that the amount of heat transmission is

$$dW = cdF\,(t_s - t)^{5/8}$$

where dW is the heat transmitted over surface dF, while t_s and t are the temperatures of steam and water respectively, c being a constant. The present tests had for their purpose, the elimination of these contradictions and the establishment of the temperature exponents for various conditions. Fig. A shows the experimental arrangement used. The water flows through a brass pipe having an inside diameter of 20 mm. (0.8 in.) and an outside diameter of 25 m. (1 in.) with a length of 2628 mm. (104.4 in.) and was heated on the outside by steam. Particular care was taken that a uniform stream of steam should be present along the entire length of the pipe so as to prevent stagnation of air. The temperature of the water in the pipe was measured by two displaceable iron-constantan thermo-elements, the voltage of these thermo-elements being measured by a very sensitive voltmeter, which permitted estimates to $^1/_{10}$ deg. cent. Since, in the same cross-section, the temperature of the water at the center was lower than that nearer the edges, in the determination of the average temperature in the cross-section a special device was used to produce eddies near the soldered place of the thermo-elements. Three series of tests were made at atmospheric pressure, and with vacuums of approximately 80 and 90 per cent. In the first two series of tests the velocity of flow of water was raised by small stages from 0.05 to 1.9 m/sec. (1.96 to 74 in./sec.) and in the test with 90 per cent vacuum from approximately 0.3 to approximately 1.5 m./sec. (11.8 to 59 in./sec.). Figs. B and C show the temperature curves which would have been obtained had the transmission of the heat been proportional to the difference in temperature and it can be seen at a



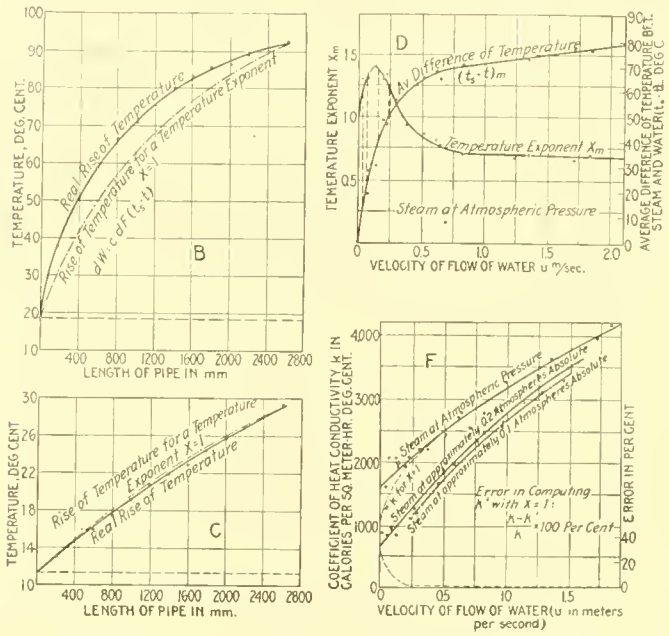


Fig. 5 Heat Transmission from Steam to Cooling Water

A Experimental Arrangement; *B* and *C* Temperature Curves for Transmission of Heat assumed to be Proportional to Difference in Temperature; *D* Average Temperature Exponent as a Function of the Velocity of Flow of Water; *E* Temperature Exponents for all Velocities of Flow of Water and Differences in Temperature; *F* Coefficients of Heat Transmission Actual and Assumed (for $x=1$) compared.

glance from a comparison of these curves with those obtained experimentally that there is no such proportionality and that the temperature exponent is, therefore, not equal to 1. In the test represented by Fig. B the exponent must be larger than 1; in the test represented by Fig. C it must be smaller. By means of a graphical logarithmic process the average temperature exponent x_m has been determined for each test and Fig. D shows this average exponent as a function of the velocity of flow of water for the three series of tests. It is evident that the temperature exponent is not constant and that it varies both with the velocity of flow of water and with the difference between the temperature of steam and water. In order to separate the influences of these two factors, a simple graphical process was again used and Fig. E shows the temperature exponents x for all velocities of flow of water and differences in temperatures between water and steam. The important result thus shown is that *the exponent varies within wide limits,* viz., *from 0.7 to 1.9 for a difference in temperatures of 70 deg. cent. (126 deg. fahr.)* All the curves for $t_s - t = 0$ coincide at certain point $x = 1$. The particles of water which flow along the walls of the pipe have a temperature which is only very little different from the temperature of the pipe walls; the closer the difference in temperatures approaches the value zero (and it appears probable that $t_s - t$ at the pipe wall is very near the value zero), the closer x approaches the value one. From this it follows that the *heat transmission from the pipe wall to the outermost layers of the cooling water is proportional to the difference in temperature for all velocities of flow of water.* The fact that the temperature exponent, as referred to average water temperature, may have as different values as are shown by the experiments is doubtless due to the fact that the distribution of temperatures in a given cross-section may be very different in various cases. Just how this distribution of temperatures occurs numerically cannot be established from the present experiments, but it has been established that there are differences in temperatures at various points of the same cross-section of water in a cooling pipe. At lower velocities convection phenomena may also play a certain part, and, since the distribution of temperatures is the cause of the difference in the values of the exponents, it appears probable that the diameter of the pipe has also a certain influence on the value of the exponent.

The results of this test are to a certain extent not in agreement with the results obtained by Mr. Orrok, who found that the temperature exponent was independent of the differences in temperatures, and for all velocities of flow of water from 0.6 to about 2.6 m/sec. has a value of $x = 7/8$. On the other hand, the data obtained by Mr. Orrok confirm and add to these tests as they have been made for small differences in temperature and high velocities of flow of water.

Further, the present tests have permitted the determination of the coefficient of heat transmission k. Fig. F shows its values as a function of the velocity of flow of water v. In order to show the amount of deviation if the coefficients of heat transmission were calculated under the assumption that the temperature exponent has a constant value $x = 1$, a curve was plotted in Fig. F. For velocities of flow of approximately 0.4 m/sec. (15.7 in/sec.) the two curves coincide, since in this case x is actually equal to 1, and even for larger velocities of flow of water, there is practically no difference between the two curves. This fact is very important for the calculation of condensers, since it enables one to use the simple formula made possible by assuming that $x = 1$, namely

$$F = \frac{Q}{k} \ln \frac{t_s - t_e}{t_s - t_a}$$

where F is the cooling surface of the condenser in *qm*, Q is the amount of cooling water per hour in *kg*, t_e is the entering temperature of cooling water and t_a the temperature of cooling water flowing out. Only in the case of very low velocities of flow of water the actual conditions must be taken into consideration and the more exact formula used. For atmospheric pressures the value of the coefficient of heat transmission may be expressed as

$$k = 1600 + 1743.v^{0.92}$$

and for a vacuum of 80 per cent

$$k' = 650 + 2090.v^{0.92}$$

The exponents of v agree with each other fully and lie between 0.72 and 0.91 (as *Zoennecken* has found in his tests) and therefore ought to be very near their actual values. The difference between k and k' is doubtless due to the decrease of the coefficient of heat transmission from the steam to the wall, when the density of the steam decreases. Numerically these values cannot yet be given since the functional relation between heat transmission and density of steam is unknown.

Co-Working of Steam Boilers Running on Different Pressures (*Das Zusammenarbeiten von Dampfkesseln verschiedener Spannung. Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 37, no. 11, p. 129, March 13, 1914. 3 pp., 6 figs. *d*). At the 43d meeting of the delegates and engineers of the International Association of Boiler Inspection Societies, which took place in Moscow, Werthwein of Barmen presented a report on the simultaneous working of boilers working with different pressures. The general development of power plants requires the application of higher and higher steam pressures, at the same time as the installation of new boiler units. As a result, especially in plants which are not new, it often happens that side by side with the new boiler group working with high pressures there are also in operation a number of the older boiler units of lower pressures. The steam of the latter is in such cases used mainly for heating, cooking, preheating of water and other purposes where high pressure is not desirable or is not of material advantage. The size of the new boiler elements of large pressure is in most cases designed in a manner such that there shall be sufficient steam not only for all available power purposes, but also to a certain extent for those demands which are primarily satisfied by the older units, and the devices which insure the collaboration of the two kinds of boilers must be arranged in a manner such that on one hand all the advantages of the high pressure and available heating surface of the high-pressure boilers shall be thoroughly utilized, while on the other hand all danger for the low-pressure boilers shall be eliminated. As far as the author is aware, there is only in Germany legislative rules governing such cases of running together boiler groups of various pressures.

The Prussian regulations of 1902 were as follows: (*a*) The steam piping from high-pressure boilers must be provided with automatically acting devices (such as reducing valves, pressure regulators, etc.) by means of which

steam flowing into the collector piping shall be reduced to the lower pressure level of the other boilers. (*b*) In front of this pressure reducing device, that is, on the side of the high-pressure boiler, there shall be a cut-off valve, if possible, such as can be operated from the floor level. (*c*) The common piping shall be provided with a small scale manometer and such number of safety valves as will maintain the pressure prevailing in the piping not in excess of that prevailing in the low-pressure boiler connected thereto. (*d*) Each of the steam boilers connected to the common piping must be provided with a slow-acting long-stroke safety valve. (*e*) Each boiler must be arranged so that it will cut off from the piping. (*f*) The feed piping of boilers of various pressures connected to a common steam piping must be kept separate.

These rules have been somewhat modified by the German law for land steam boilers of 1909 and at the present time only the first section of the above regulations is in force. Both groups, high and low pressures, will give off their steam into a common piping. In the pipe connections from the low-pressure boilers to the common piping, pipe isolating valves are installed in a manner such that the cones of the valves shall be lifted by the steam flowing from the low-pressure boiler toward the collector piping. The pressure in the collector piping must therefore be somewhat lower than that in the low-pressure boiler connected thereto and the pressure of the steam acting from the high-pressure boiler must have been correspondingly reduced by means of reducing valves or in some other manner. As regards the pipe isolating valves, the most simple construction was preferred at first, such as valves with loose ball. It was soon evident, however, that in several respects these valves were unsuitable, especially where the steam engines received their steam from the collector piping and also where only the high-pressure boilers supplied steam to the engines, while the steam from the collector piping was used for other industrial purposes, such as heating or cooking. In all such cases the pipe isolating valves produced a noise due to the valve ball striking against its setting, until finally the constant strokes destroyed both the seat and the ball, while the noise was so unpleasant for the boiler attendant that the ball was often removed and the valve became absolutely useless. To avoid these inconveniences, it was proposed to insert into the steam piping special steam collectors and to use pipe isolating valves of such a construction as to avoid the production of the noise.

Schaffer and Budenburg in Magdeburg used the pipe isolating valve shown in Fig. 6A, with the horizontal axis coming out from the casing through a stuffing box. To the stuffing box end of the axis is fixed a lever having on one end a tension spring and on the other end an oil brake. If variations of pressure occur in the piping the valve cannot fall off, owing to the damping action of the spring and brake. In many cases the spring alone, without the brake, is quite sufficient. Dreyer, Rosenkranz and Droop in Hannover have placed on the market a pipe isolating valve shown in Fig. B, with the valve cone suspended on a spring and therefore sitting much lighter than an unbalanced cone. Although a valve of this type has been placed on a collector piping from which steam was supplied to a rolling mill engine and a steam hammer, no knocking in the valve has been observed. Franz Seiffert and Co. in Berlin used a pipe isolating valve (Fig. C) where the valve cone is connected with a balanced brake piston.

All these valves have succeeded in eliminating most of the troubles occurring with the ordinary type pipe isolating valve, but in order to make possible the working of two boilers of various pressures on the same collector piping, without any undesirable occurrences and with full safety for the low-pressure boiler, additional devices have to be installed, and the above mentioned Prussian regulations indicate what these devices should be.

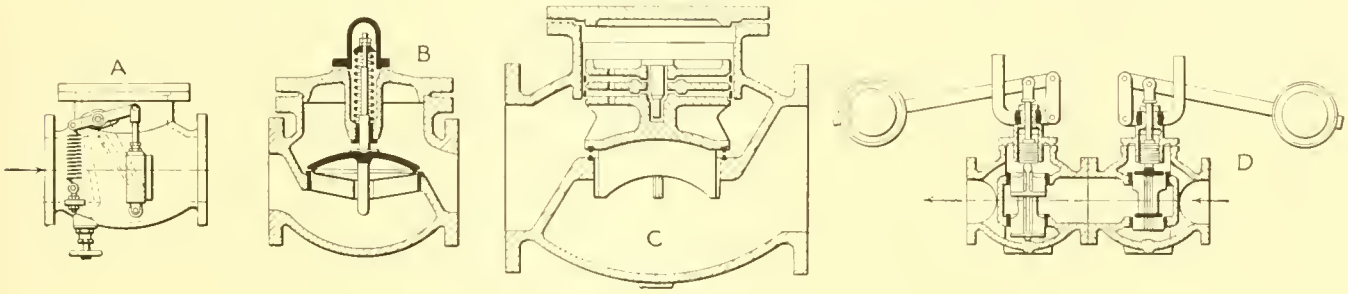


Fig. 6 Pipe-Isolating and Pressure-Reducing Valves

In the first place the steam piping running from the high-pressure boiler to the common pipe must be provided with a pressure-reducing valve by means of which the high pressure of the steam shall be reduced to the lower level and since, as a rule, these pressure-reducing valves cannot be used as stop valves, separate valves of the latter kind have to be installed, in a manner such that they can be safely and easily handled from an accessible place (best from the fireman's side of the boiler). When it is desired to maintain the steam pressure in the high-pressure boilers as uniform as possible and to let into the common piping only the excess of steam, it is advisable to employ mechanically acting devices rather than to rely on the regulation by boiler attendants. This can be done by a so-called overflow valve connected with the pressure reducing valve, one type of which (built by Schaffer and Budenberg) is shown in Fig. D. The overflow valve opens first and lets out the steam as soon as the pressure in the high-pressure boilers has reached a predetermined value, while the pressure reducing valve delivers high-pressure steam to the collector piping as soon as the pressure of the steam in that latter pipe has reached the level of the pressure in the low-pressure boilers supplying steam to the same piping. The article describes also an overflow and pressure reducing valve of Hübner and Mayer in Vienna, said to have given complete satisfaction in actual practice.

Smoke Catchers for Use in Roundhouses (*Über Rauchfänger für Lokomotivschuppen*, Gwosdz. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 12, p. 144, March 20, 1914. 3½ pp., 21 figs. *d*). The article describes a number of older types in German practice. In most of these the smokestack valve used to be closed automatically as soon as the smoke catcher funnel was raised, but arrangements might have been made to keep it in any position desired, since the funnel was low down. Further, in these older constructions, an automatic arrangement was provided for placing in the open position the throttling valve when the catch funnel was lowered down. The Prussian railway administration, in 1907, however, found that if the throttling valve on the smoke catcher was fully open there was powerful ventilation over the locomotive, and the latter, especially if it was to go out of service, was cooled down very rapidly. This sometimes produced leaks in the tubes. Therefore an order was issued that no smoke catchers should be used where the throttling valve was automatically opened.

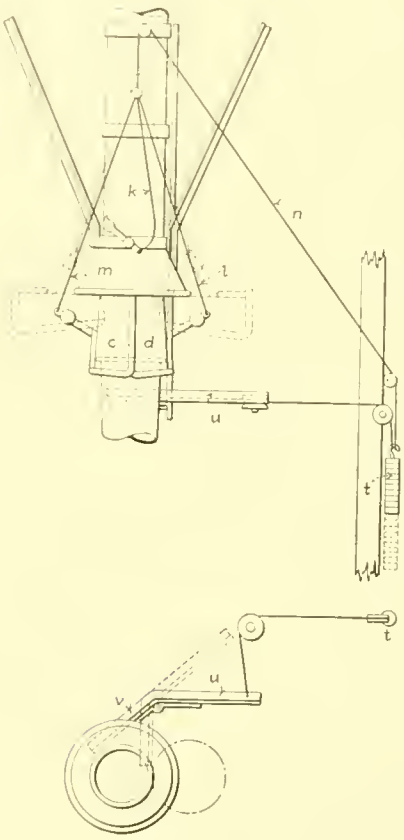


Fig. 7 Fabel Roundhouse Smoke Catcher

The article accordingly describes a number of apparatus complying with these requirements. The endeavor to make the connection between the locomotive stack and the smoke catcher pipe as close as possible led to the evolution of a special type of smoke catcher, with a divided jointing funnel.

Fig. 7 represents the Fabel apparatus constructed on this principle. The funnel consists of two nearly cylindrical clappets, *c* and *d*, which are movably located by journals and eyes on the smoke pipe and, when inclined, enclose the locomotive smokestack. By means of ropes *l* and *m*, operated by a common wire *n*, they can be placed in the position indicated by dotted lines, and the rope *k* connected with the wire *n* serves to adjust the smoke pipe clappet valve. The latter arrangement has been tested in accordance with the regulations of 1907. The disadvantage of this arrangement lies in the fact that the locomotives must stand almost exactly under the smoke pipe, since otherwise the smokestack would not be tightly enclosed by the clappets. To avoid this and also to make the catcher work with a locomotive having various heights of smokestack, the designer placed between the funnel valve and the smoke pipe an adjustable pipe extension.

Explosions in Water Tube Boilers with Headers (*Explosionen in Wasserrohrkammerkesseln*, Bracht. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 9, p. 344, February 28, 1914. 2pp., *gp*. Paper read before the Lower Rhine Section of the V. d. I.). When watertube boilers were first introduced one of the main arguments in their favor was conceded to be their freedom from explosion danger, and on this account special regulations had been instituted in Germany permitting the use of watertube boilers under conditions where ordinary types of boilers were not allowed. Later, however, several explosions of watertube boilers occurred which tended to show that this type was not so safe as supposed.

The first explosion of this kind took place in June 1912, in the boiler room of the electrical central station of the Phoenix Rolling Mills at Lerenfeld, Germany. In that plant were four boilers, three of which were made by one concern and the fourth installed in 1910 by another concern. It was this last that exploded. Its rated working pressure was 15 atmospheres, but as the other three boilers were allowed to work with only 13 atmospheres, the same pressure was maintained in the fourth boiler. The heating surface was 412 qm. and the chain grate 14.4 qm. The water headers had a width of 6 m. or 6.080 m. and were made in one piece with arches for the two boiler drums. The width of the frame was 254 mm. and the header 200 mm., the thickness of the header plates being 18 mm. The explosion may be referred back to the fact that a circulation plate in the front part of the header, which was welded in, was entirely torn away, and through the opening that formed, the water content of the boiler rushed out, while the upper part of the boiler broke away from the foundations and pipe connections, broke to pieces and was thrown 50 m. from its original place, causing considerable damage on the way. Bricks and iron pieces flew in all directions for a considerable distance. Two firemen were killed and a third died soon after. One person was seriously injured and six persons less seriously.

The second case of explosion of a watertube boiler took place in November 1912, at the iron works of Menden and Schwerte in Schwerte. Three persons were killed and two seriously wounded. The boiler was installed in 1911 to work at a pressure of 13 atmospheres gage. The heating surface was 300 qm. (3210 sq. ft.), the grate area for hand-firing, 8 qm. (85.6 sq. ft.). The boiler worked in connection with three other boilers of the same size and construction. The explosion was practically a reproduction of the Düsseldorf case. Here also without any previous warning the circulation plate of the header broke off, but remained hanging, since at the corners it had no welds. The opening

which was formed had a cross-section of about 1 qm. (10.7 sq. ft.) through which suddenly water and steam were offered a free passage. The boiler was thrown backwards to a distance of 58 meters (say 185 ft.) in the direction of its longitudinal axis, totally destroying its setting and partly destroying the other boilers, as well as greatly damaging other property.

In November 1912, occurred a third explosion, this time at the plant of the Deutscher Kaiser, at the rolling mill Dinslaken. The boiler had a heating surface of 157 qm. and 12 atmospheres gage pressure and was built in 1897. It has worked since that time with few interruptions, day and night, using the waste heat of two milling furnaces. On the day of the explosion, the boiler which had for some time been out of commission, owing to repairs on the furnaces, was to be again heated up. When the pressure reached approximately 9½ atmospheres, the explosion occurred. The boiler had not yet been connected with the steam piping. Shortly before that a noise had been heard which was falsely supposed to be due to steam escaping from the safety valve. The boiler attendant was thrown some distance and died several hours later. The boiler itself was thrown to a distance of about 6 m. (say 20 ft.). The inspection of the boiler showed that the manhole of the rear header was separated and the staybolts from the circulation plate along the welded seam broken, and that the header was drawn upwards to where it found less resistance offered by the tubes back of the superheater. The nine staybolts in the lowest row have been torn off from the tube wall, while the other seven have been torn out of the manhole wall. In the second row from below there were nine staybolts torn out from the manhole wall. The circulation plate was not deformed. As regards the nine staybolts torn out from the manhole wall, it appears that six of them were broken previous to the explosion while the other three indicated a somewhat more recent fracture.

At first it was supposed that these explosions were caused by defective work, an opinion which was at first endorsed in full by experts and even by the representatives of the manufacturers. The circulation plate was butt-welded toward the header plates and the hammer blows of the welder, which could of course have been applied only from the outside of the connection, probably caused the weld to take place in such a manner that the plate edges were superimposed. The connection between the metal elements was so slight that traces of old chiseling could easily be seen on the circulation plate. On the inside of the header the iron shavings which were used as a welding material have melted and flown into one piece with the walls so that there was available both a tight connection and a certain amount of strength. Test pieces have been cut from the plates and investigated and it was found that the walls were made of wrought iron, having strength of 34 to 41 kg/qmm. which could be easily welded. On the lateral circulation plate of the latter, the test pieces show a materially better weld than was the case on the bottom plate. These circumstances confirmed the assumption that in the manufacture of the bottom seam the art of welding may have been imperfectly applied and that for some reason the workmanship was at fault.

The manufacturer, however, would not accept this view, since the welder who worked on this header was an old worker, in the business for many years and has made many headers without any trouble. Therefore he insisted that the cause of the explosion be sought in some irregularity of operation, such as, for example, the possibility of the chamber (owing to a break in the arch) being exposed to the fire for a comparatively long time. In addition, there was considerable mud and boiler scale pieces collected in the lower part of the header which might have led to overheating of the seam and to a rupture of the parts. This assertion of the manufacturer was thoroughly investigated and may be considered as having some foundation in a certain sense. During the night before the explosion 30 to 40 bricks fell from the lower arch ring of the grate. This circumstance alone could not have caused over-heating. A case is on record where one-half of the fire arch broke down. In that case, however, part of the arch which broke was near the hopper, and for operative reasons the work of the boiler had to be continued for a certain time, this being done by closing the wall by a fire sheet so as to prevent a false entrance of air. In both cases, fault of attendance can therefore be left out of consideration, although it must be admitted that an overheating of the plates had taken place, as shown by blue spots in one place on the plate.

It is hardly possible to admit that the presence of mud and boiler scale inside the boiler intensified over-heating, since, water of condensation with 5 per cent supplementary water, which passed previously over a cleaner, was used as feedwater. In addition, owing to the inclined position of the header, in the lower part of the latter there was a sort of dead angle in which all the impurities present used to deposit. The speaker was therefore of the opinion that in this case also the cause of the explosion lay not in the defective workmanship of the seam but in a defective method of setting of the boiler which had not sufficiently protected the seam from overheating. In the Schwerte explosion it was found that the circulation plate and the lower part of the header wall showed blue spots, while inside the walls was found a scale deposit of 5 to 8 mm. (0.2 to 0.32 in.) thick, while the mud contained a considerable amount of oil. It appears further, that the overheating of that particular spot was also intensified by the fact that the protective setting of the header was partly broken and crumbled up. Here also, therefore, the setting had not afforded sufficient protection to the seam and the overheating finally caused its failure.

The third case in Dinslaken is materially different. Overheating did not seem to have played any material part in the accident which appears to have been brought about mainly by the failure of the staybolts, which were placed too far away from the edge (200 mm. or 8 in.) so that the seam was stressed too high.

The author discussed further the lessons which can be drawn from these explosions and the preventive measures which should be taken to avoid their repetition. The Central Association of Prussian Societies for the Inspection of Boilers has decided to carry out a series of experiments by building a number of test headers in order to test thoroughly the distribution of strength, not only in headers which have been produced by butt-welding, but also of those which have been produced by other methods without welding. These tests have not yet been completed. The author had occasion to be present at tests when all boilers had been broken by water pressures, butt-welds had broken at pressures from 50 to 60 atmospheres, the butt-welds here used being of the

same type as in the exploded boilers. This would indicate that the butt-weld, although not an ideal method of making a seam, was still strong enough to bear all regular strains. But in the operation, suitable conditions must be maintained, and if this were done, the faith in the reliability of the double header boiler might be recovered. In Germany there are now 15,000 to 20,000 of such boilers at work and giving good satisfaction, and the few cases of explosions, though certainly regrettable, ought not to prejudice against this type of boilers.

Strength of Materials and Materials of Construction

Testing Fire Bricks (*Die Prüfung feuerfester Steine*, A. Gary. *Feuerungstechnik*, vol. 2, nos. 11 and 12, pp. 178 and 199, March 1 and 15, 1914. 9 pp., 14 figs. *dp*). Prof. A. Gary, head of the great experimental station at Gross Lichterfelde West, presents in the present article a description of methods used for testing fire bricks, covering the following subjects: Chemical composition of the brick, determination of its shape, consistency, space, weight, specific weight and density, volume after repeated heating, compression and expansion, variation of length with heating, heat conductivity, melting temperature as compared with that of Seger cones, softening and change of consistency in heating and in contact with other bodies, compression strength when cold or hot, and porosity with respect to gases. The author discusses in detail the methods used and suitable apparatus for determining all these factors.

Heat Conductivity, Specific Weight and Porosity of Refractory Materials (*Wärmeleitfähigkeit, spezifisches Gewicht und Porosität feuerfester Steine*, P. Goerens. Cp. *Feuerungstechnik*, vol. 2, no. 12, p. 204, March 15, 1914. *e*). Paper presented by Prof. P. Goerens at the 34th meeting of the German Association of Manufacturers of Refractory Materials. In establishing a heat balance of metallurgical processes, under the heading "heat losses through conduction and radiation" are given values which evidently require to be corrected. This is due to lack of proper methods for determining these losses and to their determination as the difference between computed input and output of heat, so that, for example, in some of the blast-furnace heat balances the heat losses over radiation and conduction varies from 0.58 to 33.3 per cent of the total heat. These wide variations are in the first place due to the fact that practically all the errors in other observations are lumped up under the heading "heat losses through conduction and radiation."

Engineer J. W. Gilles has performed a series of experiments in the Metallurgical Institute of the Aix la Chappelle Technical High School, using bricks of normal type in order to determine directly the heat conductivity of fire brick. The apparatus consists of an electrically heated plate, by means of which the surface of the brick was heated, a calorimeter for the determination of the heat coming through, and a number of thermoelements for the determination of the distribution of temperature in the mass of the brick. In addition to the heat conductivity of the brick there were also determined its true specific weight g_w, apparent specific weight g_s and the absolute porosity P_{abs} determined from the formula

$$P_{abs} = \frac{g_w - g_s}{g_w} \times 100$$

From these data it appears that the absolute conductivity increases with the temperature in the case of fire brick, half fire brick, slate, lias, silica and carbon, but noticeably decreased in magnesite. Further, in chemically similar refractory substances, the heat conductivity decreases with porosity.

ENGINEERING SOCIETIES

AMERICAN RAILWAY ENGINEERING ASSOCIATION

Bulletin, vol. 15, no. 163, January 1914, Chicago, Ill.

Report of Committee on Iron and Steel Structures
Report of Committee on Masonry
Report of Committee on Wood Preservation (Abstracted)
Report of Committee on Grading of Lumber

Report of Committee on Wood Preservation (54 pp., 28 figs. *eA*). The report on wood preservation discusses the use of oil from water gas and coal tar in creosote oil, and comes to the conclusion that wherever possible only grade 1 coal tar creosote should be used and under no circumstances should coal tar be added to creosote of this grade. Where it is advisable to use coal tar in mixture with the lower grades of creosote, such as grades 2 and 3 of the American Railway Engineering Association and poorer, the following precautions should be adhered to: There must be a distinct understanding between all concerned that a mixture as specified is used; the coal tar should be added to the creosote only at the plant and under the direct supervision of the railway company; under no circumstances should the coal tar constitute more than 20 per cent of the mixture. The coal tar and creosote should be thoroughly mixed at a temperature of approximately 180 deg. fahr. before being applied to the timber, the tanks containing the mixture being heated and agitated thoroughly before any oil is transferred to the working tanks. Only low carbon coal tar can be used. The amount of free carbon should not exceed 5 per cent, and in treating with the mixture, the temperature of the solution in the cylinder should be not less than 180 deg. fahr.

The article quotes records from service tests with periodical inspection of the sections of test tracks of various railroads as well as the methods of determination and valuation of various values under test. In an appendix is given an extensive discussion by Hermann von Schrenk and Alfred L. Kammerer on the use of refined coal tar in the creosoting industry in which the authors object to the view of considering coal tar additions as adulterations, and by a series of experiments come to practically the same conclusions as stated above, insisting upon the necessity of stopping the practice of selling creosote oil mixed with coal tar as No. 1 grade oil.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. 26, no. 1, February 1914, Washington, D. C.

A Method of Closing Pores on Hollow Brasses, Capt. F. W. Bartlett, U.S.N. (4 pp. *p*). On the U.S.S. Montana it was found that the six bottom brasses for the main shaft of each engine were porous, so that water from the water service mingled with the oil of the journals to a slight extent. The babbitt metal of the brasses, however, was in excellent condition and the leaks were not where the babbitt was located, but at other points of the brasses and at points where the babbitt was cut away. As it was a very expen-

sive proposition to fit new brasses, the following method for making tight the old ones was attempted and found successful.

Method Used. The brasses were first filled with gasolene and subjected to a pressure of about 20 lb. and left in this condition for about 12 hours. It was found that the gasolene worked its way through the crevices and appeared at the small openings, and in some cases carried with it what appeared to be particles of red lead, giving the impression that an attempt had been made at some time to close these crevices by forcing in red lead under pressure; but this could not be proved. The idea of using the gasolene was thoroughly to clease the crevices of oil and water. The gasolene was then removed and air blown through for four hours and the brasses were then filled with shellac and a pressure of 75 lb. of compressed air was put on this shellac and it was kept in this condition for about four hours, the idea being that the shellac would not settle materially in that time. It was found that the alcohol appeared to push ahead of it small particles of water or gasolene, and appeared as drops at the small crevices, and in some cases the shellac could be seen clearly to have passed through these crevices and to have arrived on the outside as a brown liquid. This, however, soon congealed and no further leaks took place. The shellac was then removed and compressed air blown through the brasses for three or four hours with the idea of setting the shellac on the surfaces within, although it was realized that the shellac in the small crevices would be in no way affected. After this the brasses were filled with water and tested to a pressure of 75 lb., with no sign of leakage after an hour of observation.

Shellac was the material which seemed best adapted for this purpose over all others considered, but it is believed that some other material might be found to accomplish this purpose, and a material which would not become soft at as low a temperature as shellac. Experiments along that line should be conducted.

INSTITUTION OF ELECTRICAL ENGINEERS

Journal, vol. 52, no. 231, April 1, 1914, London

Steam Boiler Working in Electrical Power Stations, J. W. Jackson (7 pp., 4 figs. *g*). The author points out that the watertube boiler has been adopted almost universally on account of the ease with which it deals with fluctuations in the load. He advocates the straight-tube vertical boiler, but remarks that the designing of these boilers is by no means a simple matter, some difficulty being experienced in arranging the drums to accommodate the extra number of tubes without, at the same time having to press the drum ends or sides into bad shapes.

Modern competition appears to have called for a superheater of a smaller area, but placed in a much hotter portion of the boiler. In dealing with this question the author shows a strong preference for the arrangement illustrated in Fig. 8A. These superheaters, designed ten years ago with ample surface, were fixed in the boiler at a distance much further from the furnace, with the result that they are much steadier to work and of almost everlasting wear. They also have the advantage that the amount of superheat can be reduced without overheating the tubes. The author assumes that the fixing of the comparatively small superheater (Fig. B) in such a hot position of the boiler is due to first cost, but he considers the difficulties in operation are increased as regards maintenance, reliability and control. He also thinks that, as really high superheated steam is coming into use and steam temperatures of from 700 deg. fahr. to possibly 900 deg. fahr. at the turbine stop valves are likely to be required before very long, troubles will increase somewhat alarmingly if the superheater of the future is fitted in such a hot position of the boiler.

The author discusses many other details of modern boiler practice, as the design of boiler furnaces, Co_2 indicators, firebricks, stokers, pneumatic and hydraulic ash-handling systems, feedwater treatment, etc.

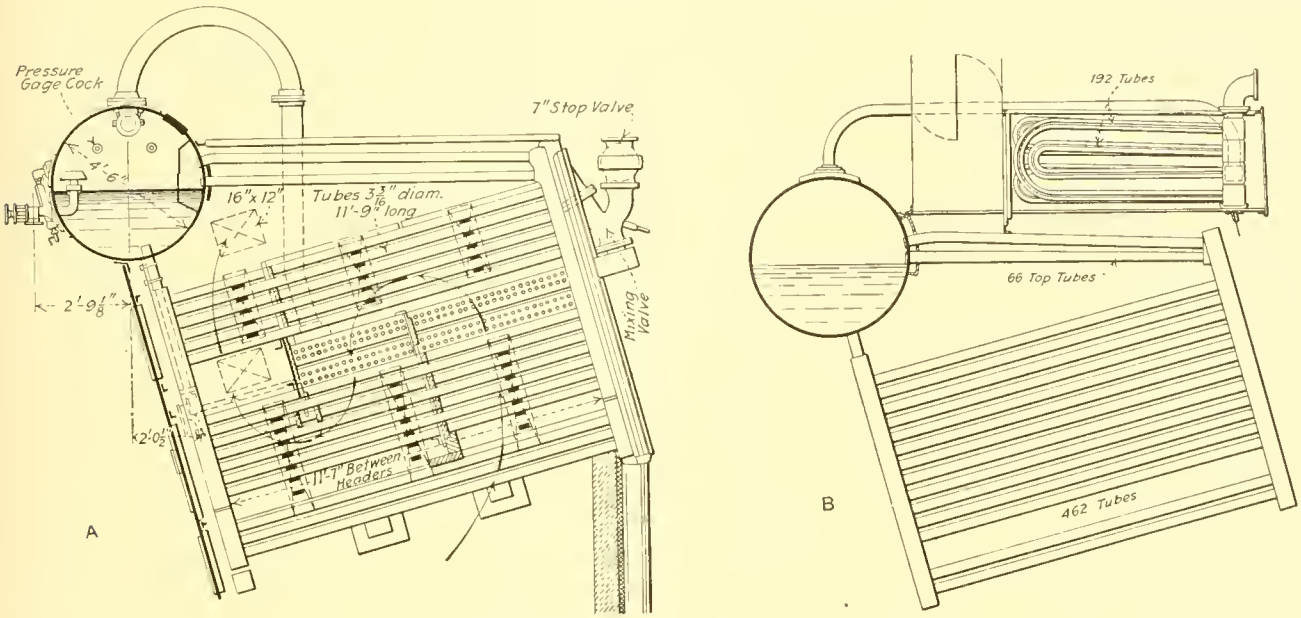


Fig. 8 Superheater Location in a Modern Boiler Plant

MANCHESTER ASSOCIATION OF ENGINEERS

Sun-Power Plant, Frank Shuman. At a meeting of the Manchester Association of Engineers in Manchester, March 11, 1914, Frank Shuman read a paper on the Sun-Power Plant. As the Proceedings of this association are not yet available, this abstract is made from an account in Engineering, March 27, 1914. The cost of producing power from sun rays appears to be such that sun-power plants for the present need not compete with plants using coal at any tropical place where coal is reasonably cheap. Work had to be confined to places where the sun was at its best and where coal cost from £3 to £8 a ton. The speaker then described in detail the engine which he constructed for the pumping plant at Meadi, near Cairo, Egypt. The steam is generated in five sun heated absorbers arranged in a manner such that they are always facing the sun throughout its course during the entire day. The calculations given by the speaker show that with coal at £3 per ton there was in the Meadi plant a saving of £410 per annum, with the extra first cost of £790 of the sun-power plant over that of the coal consuming plant, so that in less than two years the saving in fuel would cover this extra cost.

NEW YORK RAILROAD CLUB

Advance Paper presented at April 17, 1914, Meeting, New York

The Art of Locomotive Staybolts, C. A. Seley (6 pp., 2 figs. *dp*). The locomotive boiler is a structure which is severely taxed, as a result of which there are numerous cases of staybolt breaks. Under the Interstate Commerce Commission Code of Rules no boiler shall be allowed to remain in service where there are two adjacent staybolts broken or plugged in any part of the firebox or combustion chamber, nor when three or more are broken or plugged in a circle four feet in diameter, nor when five or more are broken or plugged in the entire boiler. The cost of repairing a broken staybolt is not simply that of the labor and material employed, but also some portion of the value of the service of the engine, from $25 to $100 per day, which is lost thereby, and this makes it very important to have the staybolts stay up as long as possible. With a well-designed and built boiler equipped with solid staybolts, there should not be any serious trouble until about the third year of its use. Length of staybolts has much to do with their relative rigidity. There appear to be what may be called "breaking zones," which, generally speaking, include the end and top rows of side sheets, outside rows on back heads, most of the throat sheet bolts, and in large boilers all the stays of combustion chambers to the shell sheet except the radials. The radial stays securing the crown sheet are generally long enough to have the necessary flexibility which prevents their breakage except those which stay the upper corners of the firebox. These corners are arches, very stiff and rigid as compared with other parts of the box, and as the stays are not truly radial to the outer sheet, the staybolt holes are tapped at an angle with more or less of incomplete threads. Experiments have been made showing that the relative expansions of the firebox and outer boiler sheets, when under pressure, are not alike and their staybolts, in addition to the tensile load imposed by the pressure, have also an angular strain due to these irregularities. It is these angular movements many times repeated that account for broken staybolts after the direct cause is taken care of by the relatively high factor of safety. It appears that staybolts do not break on account of lack of strength of the cross section, but on account of the overstressing of the outer fiber due to angular vibration. Rapid and uneven heating of the firebox in firing up, as well as in cooling down and washing, produces the greatest amount of angularity and accounts for the unusual checks, although at these times there is no pull on the bolts. The location of the fractures is significant. As a rule a solid staybolt breaks close to the outer sheet, apparently because it is heavier than the fire sheet, is stiffer, does not respond by buckling, and therefore acts in a way as a foundation. The speaker asks whether the rigidity of the sheets does not cause them to act as levers in the staybolt holes of the firebox sheets, and on the material around the holes, stressing it to the point of failure and accounting for the cracking of sheets, which must have a starting place, and that at the bolts and not between them. The remedy for this would be more flexibility on the body of the bolt between the sheets to reduce the stress on the outer fiber and also reduce their strength as levers to punish the firebox material, reduce the buckling and save the fireboxes.. One of the more recent developments in the art aims directly to increase the flexibility of the body of the staybolt to eliminate breakage and also save the firebox sheets by the simple expedient of making staybolts with a body of two pieces of half-round iron, thus having two neutral axes each much closer to the outer fiber than in the solid section, and then by twisting the body present the plane of greatest flexibility in each direction in which the latter turns. The comparison of such a structure with that of the solid bolt is shown in Fig. 9.

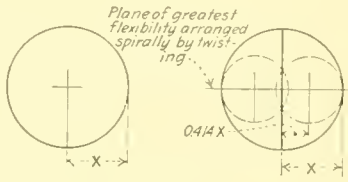


Fig. 9 Two-Piece and Solid Staybolts compared

SOCIETY OF AUTOMOBILE ENGINEERS

Vol. 5, no. 6, March 1914, New York

Influences Affecting the Fundamental Deflections of Leaf Springs, D. Landau (36 pp., 15 figs. *etA*). There appear to be a very large number of variables that affect the flexibility of springs, making this branch of engineering a highly specialized work. The formulae often called for the deflections of a leaf spring are all based on the theory that the spring is a beam encastré at one end and loaded at the other end, or that it is a beam supported at its ends and loaded in the middle. There is no room to doubt that the partial lengths of a spring are to be regarded as cantilevers with loads at their free ends. All efforts, however, to obtain an equation which would cover this piece of apparatus have been unsuccessful. One of the faults lies in the assumption that in a spring, the leaves of which are of the same thickness and decrease in length by equal steps,

the leaves are under a uniform stress and on that account the spring bends to the arc of a circle.

The author strongly objects to the assumption that the modulus of elasticity varies in spring steel. Heat treatment, no matter how varied, has no influence on this coefficient, as the author proves by numerous data of tests, showing that methods of preparation, heat treatment and chemical composition seem to have no practical influence on the property of stiffness. Carbonization and hardening of the surface are also without effect on the value of the modulus of elasticity. Further, the investigations of Henry W. Bearce have shown that there is a slight increase in the modulus at the elastic limit and that Hooke's law holds at the elastic limit, neither does the modulus appear to vary with time and rest, as shown by investigations made in connection with chronometer balance springs. From the investigations of William Dalby, the author concludes that, so far as this kind of spring steel is concerned, tempering the steel has very little influence on the value of the modulus of elasticity.

The apparent difference of stiffness in various cases may often be accounted for by other considerations: First, two plates of spring steel of the same nominal dimensions, and of different or the same chemical constitution, coming from two different rolling mills, will usually be found to be of different thicknesses, sometimes with a variation as great as 0.005 in., which is enough to account for the observed difference in flexibility. Springs pass through a number of operations before they are ready for assembling. They have to be trimmed, milled, fitted and heat-treated; for every one of these operations the plate has to go into the furnace and every insertion into or removal from the source of heat produces a certain amount of oxide or scale which decreases the working thickness of the plate, with the result that the plate will be thinner than the normal thickness by an amount depending on the number of heats that it has to undergo. The author describes the basis of providing for this thinning of the leaves. The grinding of both sides of the leaves of high-grade touring car springs is gradually being discontinued, because it is not improbable that two different workmen with different grindstones may turn out leaves which only appear to be identical, and the finished springs will show a marked difference in flexibility.

The friction of plate springs plays an important role in the operation of a spring. A spring freshly lubricated will execute its oscillation more freely than one that has been allowed to rust and run dry. A case is recorded of a spring loaded to its correct height for several months taking an apparent set of nearly an inch on releasing the load. The investigations show that the "set" was due to rusting, and the spring was restored to its initial height by putting oil between the leaves and causing it to oscillate. The author quotes Professor Dalby's investigation on internal friction, but disagrees with him on some particulars.

As regards shackles, there is very little published information. The two considerations with which the spring engineer is concerned are the effect of tight shackles on the freedom of action of the spring and the effect of the obliquity of the shackles on general shape of the springs to which they are attached. The author discusses both of these points in full. The effect of placing a shrunken band on a leaf spring is to increase its stiffness. Some investigators have considered the full length of the band to be effective in clamping the springs, but experiments conducted under the author's direction indicated that this assumption is incorrect, and it appears that only about 0.4 of the length of the band is efficient (complete data on these banding tests are given in the article).

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 19, no. 3, March 1914, Chicago, Ill.

THE CEMENT GUN AND ITS WORK, Carl Weber (35 pp., 24 figs. *dp*). The product of the cement gun is called "gunite" in order to distinguish it from ordinary cement stucco or plaster work, and for the reason that the material develops qualities which put it in a class by itself. Gunite is usually a cement mortar composed of about one part of portland cement and three parts of coarse, sharp sand passing through a 3/8-in. screen.

The material leaves the nozzle with a velocity of about

RESULTS OF COMPARATIVE TESTS

Made to compare the properties of handmade stucco with gunite
This table is computed from independent investigations made by Westinghouse Church, Kerr & Co. Engineers, N.Y. Given in detail in their report of Nov. 1, 1911
MIXTURE 1 TO 3
Dykerhoff Portland Cement and Cow Bay Sand passing 1/8 inch screen

TEST MADE FOR	RESULTS HAND	RESULTS GUN	RATIO DIAGRAM (Handwork / Gunite)	RATIO
TENSION *lb per sq in*	254	441	0 254 441	1.74
COMPRESSION *lb per sq in.*	2084	3530	0 2084 3530	1.70
VOIDS *Percentage*	19.2	12.7	0 12.7 19.2	0.66
PERMEABILITY *Com per hr on 0.02 °m*	3.0	0.44	0 0.44 3.0	0.15
ABSORBTION *Per Cent by Weight*	5.1	3.67	0 3.67 5.1	1.40
ADHESION *On brick lb per sq in*	272	386	0 272 386	1.42

FIG. 10 HANDMADE STUCCO AND GUNITE; RESULTS OF COMPARATIVE TESTS

300 ft. per sec. and as it strikes the hard surface the sand will rebound and fall down. Only the neat cement will first adhere until a coat thick enough to hold the sand has been formed. Then the rebound stops almost entirely and the coat is built up grain by grain until the required thickness has been obtained. In this manner a film of neat cement is automatically formed between the old and the new work on every inch being covered, thus sealing every pore.

As the "shooting" continues the forcing ahead of the neat cement by impact is continuously repeated, and every grain of sand which does not find a perfect bed or which is not immediately enveloped with cement will rebound and be forced out. Any pores remaining will be immediately filled by the following mass and all air and surplus moisture is forcibly ejected.

Field and laboratory tests were made by Messrs. Westinghouse, Church, Kerr & Company, of New York, to compare the qualities of handwork with gunite. The final report which very elaboately shows in figures, words and photographs, all the different testing machines and methods employed, gives the results of these tests as follows:

"In all of the tests made the product of the cement gun showed superior to good handmade products of the same kind. The degree of superiority varied between wide limits.

In tensile strength the gun work excelled hand work in every case by amounts ranging from 20 to 260 per cent.

In compressive strength the excellence of the gun work was even more marked, ranging from 20 to 720 per cent better than hand work.

In the matter of surface permeability the gun work absorbed from 710 down to 120 as much water per hour, per unit of area as the similar handmade surfaces.

As regards absorption of water, the handmade mortars took up from 1.4 to 5.3 times as much as the gun-made mortars.

The percentage of voids of the gun-made product ranged from 52 to 75 per cent to that of the handmade mortar.

The adhesion of the gun-applied mortars was on an average 27 per cent better than that of the hand work."

In order to show, in condensed form, the comparative values of results of these tests, the author gives a ratio diagram for the one-to-three mixture as shown in Fig. 10.

Although these tests greatly favored the handwork, they prove conclusively the superiority of gunite. The cement gun gives a perfect bond and forms a coating of a density which it is impossible to produce by any other known method.

Main Entrance to the Engineering Societies Building, New York. This entrance opens upon the large foyer which occupies the whole of the first floor and is a congregating place at times of conventions. Ordinarily one enters by doors at the left of the main entrance, which lead directly to the elevators. At the time of meetings, however, the center doors are swung open to visitors. Every engineer, the world over, is welcome here.

PERSONAL NOTES

Fifty-three lantern slides with descriptive notes on the Engineering Societies Building, the home of the Society, are at the disposal of the local sections and student branches of the Society, and may be secured upon request from the Secretary.

Elliott H. Whitlock, Manager of the Society, who has been connected with the carbon industry and the management of plants in other lines for nearly eighteen years, has recently opened his own office in Cleveland as consulting engineer and carbon expert. Mr. Whitlock is naturally familiar with all the details of carbon manufacture and its economical production. He will specialize also in efficiency management, installing new methods in manufacturing concerns which are not now on a paying basis, so that they may continue on a sound basis.

Theodore T. Mersereau has been appointed inspector of steam and motor vessels for the inland waters of the State of New York, under the Department of Public Works, with headquarters at Albany. He has been for the past five years Atlantic Coast representative for the Kingsford Foundry & Machine Works of Oswego, N. Y., in the marine boiler department. Mr. Mersereau still retains his membership on the advisory committee for marine engineering of the West Side Y. M. C. A. school of marine engineering, now in its tenth year.

At the annual meeting of the Polytechnic Institute of Brooklyn Student Branch on April 25, Calvin W. Rice, Secretary of the Society, delivered an address.

Julian Richmond, assistant engineer of the Board of Water Supply of New York, has been commissioned to establish the city exhibit at the International Urban Exhibition to be held at Lyons, France, between May 1 and November 1, and will sail for France within a few weeks.

Stewart M. Marshall, formerly chief engineer of the Cambria Steel Company, Johnstown, Pa., has accepted the position of assistant general manager of A. J. Haws & Sons, Ltd., of the same city.

The New York office of the Mumford Molding Machine Company was closed April 1, and E. H. Mumford, vice-president and general manager, has moved his office to the factory in Chicago, Ill., in order that he may be in close touch with the business.

Chester W. Wilson, until recently associated with the Saco-Lowell Shops, Lowell, Mass., has accepted the position of assistant superintendent of the Dolphin Jute Mills, Paterson, N. J.

C. J. Kryzanowsky has become connected with The Crown Cork & Seal Company, Baltimore, Md. He was formerly in the employ of the General Motors Company, Detroit, Mich.

Bernard M. Fine, who was until recently draftsman of the Standard Roller Bearing Company, Philadelphia, Pa., has accepted a position with the Dunlap Wire Wheel Corporation of America, Richmond Hills, L. I., N. Y.

Norman B. Roper has become general superintendent of reduction works of the Backus & Johnston Company, Casapalca, Peru, S. A.

William F. Austin, until recently superintendent of the Eddystone, Pa., plant of the Belmont Iron Works, has accepted the position of superintendent of the New England Structural Company, Everett, Mass.

C. Howard Bartlett is now vice-president of Chas. A. G. Winther Company, Inc., Boston, Mass. He was formerly construction engineer with the Stone & Webster Engrg. Corporation of the same city.

John E. Fulweiler has accepted a position with the American Gas Utilities Co., Atlanta, Ga., as engineer. He was until recently associated with Perkins, Fulweiler & Company of Philadelphia, Pa.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a meeting on April 1 of the Armour Institute of Technology Student Branch, W. A. Blonck read a paper on Modern Boiler Room Operation, which was illustrated by lantern slides.

CARNEGIE INSTITUTE OF TECHNOLOGY

The Carnegie Institute of Technology Student Branch held a meeting on March 16, at which Geo. S. Cooper, Mem. Am. Soc. M. E., spoke on the Buckeye Locomobile. Mr. Cooper traced the history and development of the locomobile from its origin in Germany to its present state; he then continued with the advantages to be gained from the adoption of the unit power plant, giving results that have been obtained from this kind of motive power under test, which showed the steam and coal consumption to be exceedingly small. The paper was illustrated by lantern slides and a general discussion followed.

COLUMBIA UNIVERSITY

Target Practice was the subject of the talk given by Lieut. B. R. Ware, U.S.N., before the Mechanical Engineering Society of Columbia University on March 18. Lieutenant Ware first pointed out the importance of target practice, citing how superior marksmanship in the Spanish-American and Russo-Japanese wars played the leading part in the victories. He then explained to the audience the method of range finding, the extensive systems of communication within the ship, and the control and firing of the big guns. As an illustration of the damage wrought by the huge shells, and the accuracy of the gunners, Lieutenant Ware told of the target practice on the old Texas, where conditions were made as nearly as possible like actual battle conditions. A general discussion followed the address.

KANSAS STATE AGRICULTURAL COLLEGE

The first regular meeting of the Kansas State Agricultural College Student Branch was held March 5. Prof. Roy A. Seaton, Junior, American Society of Mechanical Engineers, gave an extemporaneous talk on Centrifugal Air Compressors, discussing the development of the compressor, its application and desirability of use. W. W. Haggard gave a review on the operation of large boilers, pointing out the method of testing for efficiency and system of management. W. A. Buch reviewed the papers published in the January and February issues of The Journal, with special reference to the more theoretical articles.

LEHIGH UNIVERSITY

Geo. P. Nachman gave a brief talk on Improved Gear Cutting Methods, at a meeting of the Lehigh University Student Branch on March 24. His talk summarized the means used to form spur gears, and touched on the Fellows gear shaper. Calvin W. Rice, Secretary of the Society, followed with a short address on the Greater Appreciation of the Engineer. A social evening followed.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On March 25 Henry K. Rowell, Member American Society of Mechanical Engineers, gave a detailed discussion of his experiences in the layout of cotton mills, and illustrated his talk with lantern slides.

On April 1 Ralph E. Curtis, Member American Society of Mechanical Engineers, gave a unique talk on the Purchasing of Supplies. He dwelt at length upon the importance of an intelligent description of what was wanted; touched on the financial and organization element, and concluded with an appeal for coöperation between the engineer and the purchasing agent.

OHIO STATE UNIVERSITY

On March 25 the Ohio State University Student Branch were the guests of the electrical engineering student branch of the same university. The address was delivered by R. E. Rohrer and J. J. Linebaugh of the General Electric Company on The Electrification of the Butte, Anaconda and Pacific Railroad Company.

On April 1 Prof. Wm. T. Magruder, Member American Society of Mechanical Engineers, lectured on the Engineering Societies Building in New York, and illustrated his talk with lantern slides. A number of students from the mining and electrical engineering student branches were present.

POLYTECHNIC INSTITUTE OF BROOKLYN

On April 4 Carl F. Dietz, Member American Society of Mechanical Engineers, spoke before the Polytechnic Institute Student Branch on the subject of Grinding. Mr. Dietz brought samples of grinding from the Norton Grinding Company, as well as numerous lantern slides, all of which demonstrated that grinding has had a marked influence on machine shop practice, and that its consideration in the engineering world demands careful study by the engineer.

RENSSELAER POLYTECHNIC INSTITUTE

At a meeting of the Rensselaer Polytechnic Institute Student Branch on March 26, A. Padron described the Uniflow Engine, including a graphical method for determining the best compression for a given cut-off. Prof. A. M. Greene, Jr., Member American Society of Mechanical Engineers, followed with an illustrated lecture on the Engineering Societies Building in New York, which was illustrated by lantern slides.

On April 13 C. Finch presented a paper on the Design of a 700-H.P., Double-Runner, Horizontal Hydraulic Turbine, and W. Schutz on the Design of a 400-H.P., Three-Cylinder Diesel Engine for Marine Service.

STEVENS INSTITUTE OF TECHNOLOGY

On February 24 Stevens Engineering Society was addressed by Edwin B. Katte, Member American Society of Mechanical Engineers, on the Electrification of the Grand Central Terminal. The lecture was illustrated by lantern slides giving in detail the development of the electrical equipment of the New York Central Railroad, showing the new and the old type of electrical locomotives, methods of distributing power, and detail descriptions of the power houses.

On March 13 Arthur E. Kennelly, professor of electrical engineering at Harvard University, delivered a lecture on Submarine Cable Telegraphy. The manufacture, operation and repair of cables were fully described by one who enjoys an enviable reputation as an authority on the subject.

Henry Hess, Member American Society of Mechanical Engineers, was the speaker at the meeting of March 24, and chose as his topics: Engineering Manufacture and Profit and Loss; and Color Photography.

UNIVERSITY OF CALIFORNIA

The following papers were read at the meeting of the University of California Student Branch held March 24: Methods and Means of Water Purification, G. A. Bush; The Depreciation Factor in Business Ventures, G. H. Briggs.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Section was addressed on April 14 by Kenneth C. Grant, Member American Society of Mechanical Engineers. Mr. Grant's subject was Flood Prevention in the Great Miami Valley. He cited the natural and artificial causes of floods and enumerated three general prevention methods. The work that has been done by the Dayton Flood Prevention Committee was outlined and the results given of the engineering studies made under the direction of this committee. The studies showed that the cost of channel improvements would be prohibitive and that such improvements would seriously increase flood damages in the communities located in the lower valley, but that the entire valley could be protected by a system of seven "dry" reservoirs at a cost of about $17,000,000. The Conservancy Act of Ohio, necessitated by the lack of legal machinery for the coöperation of the various interests that would be benefited by the wide-spread flood protection afforded by the reservoirs, was explained in detail. Mr. Grant illustrated his talk with numerous lantern slides showing views of the Miami Valley during the flood of March 1913, and of some of the largest flood prevention reservoirs of Europe. In connection with the latter, it was stated that concrete had found little application in Europe for reservoir construction, broken stone being favored.

UNIVERSITY OF ILLINOIS

A meeting of the University of Illinois Student Branch was held on April 10, and Prof. O. A. Leutwiler, Member American Society of Mechanical Engineers, was the speaker of the evening. His topic was the Voting Machine, a subject on which he is well versed, as he was one of the committee appointed by the Governor to investigate the voting machines prior to their installation in Chicago.

UNIVERSITY OF KANSAS

At a meeting on April 2 of the University of Kansas Student Branch the following topics were discussed. Present Trend in Mechanical Features of Automobiles, C. L. Coggrins; and Up-to-Date Methods of Freight Handling on Large Railway and Steamship Terminal, D. B. Kliehege.

On April 16 W. L. Burdick presented a paper on Patent Laws, in which he gave a history of patent laws in this country and Europe. He defined patent as the exclusive right to manufacture, sell or use an article. A patentable article must be new and novel, and must be useful. Any new and useful art, machine, manufacture, composition of matter or design is provided for by law. If a description of the article has been published, or has been offered for sale for two years or more, it cannot be patented. Anyone can take out a patent, but the inventor or designer himself must make the application. The petition must contain a description of the article, followed by the claim of the originator, and accompanied by a fee of $15. Final papers, if secured, cost an additional $20. If two parties petition for a patent for the same thing at about the same time, this state of affairs is termed an "interference." The following points were brought up in the discussion: Prof. F. H. Sibley told what the phrase "patent applied for" meant; W. J. Malcolmson asked if manufacture of an article forestalled getting it patented; Mr. Allison discussed obtaining patents in foreign countries, and C. L. Coggins began the discussion concerning the rights of an employee who invented a device. Prof. J. D. Garver enlarged on the master and servant doctrine and the ethical relation to the engineer.

UNIVERSITY OF MINNESOTA

At the April meeting of the University of Minnesota Student Branch the following members of the faculty were elected to honorary membership: Wm. H. Kavanaugh, John Van S. Martenis, S. Carl Shipley, Frank B. Rowley, and W. H. Martin, all members of the Society. The operation of Large Boilers, by J. W. Parker and published in The Journal for February, was the subject of a review by A. L. Buenger. C. F. Shoop, of the department of experimental engineering, presented a paper on the Standard of the Engineer. He said in part: "The public holds many professions in higher esteem than the engineering profession, and in many respects the public is justified in its opinion. This is due to our apparent lethargy and lack of a spirit of aggressiveness along lines which largely con-

tribute to the molding of public opinion. The public demands that we take a more active part in public problems and issues; public sanction makes it a duty, a responsibility; and our professional dignity and standing is seriously affected by our lack of public spirit. Failure to fulfil duty in respect to public affairs creates a suspicion as to our ability. Many men possess the inert qualifications necessary for a higher standing, yet practically preclude themselves from possible advancement by lack of action. In general, the engineering field is complex and intricate and requires for a full solution of its problems the expenditure of much more mental energy and apparent fatigue than is required in many of the so-called learned professions. Furthermore, its works and achievements do not in general receive the equivalent credit and deserving recognition. A physician can conceal his mistakes, a lawyer gloss over an unfavorable decision; their dealings are to a large extent with individuals; but the engineer dealing with the public must be prepared to withstand public censure. Then if the engineer is not a forcible man of affairs, he cannot carry a compelling recognition to the public mind. Many of us are cognizant of the above facts. We lower our standard by the stain of false impression due to lack of action. Some of us seemingly do not care, while others lack the confidence and persuasive power in speech due to lack of practice. While it is true that fluency in speech is a gift possessed by few, it is believed that the essential elements of public speaking are susceptible of cultivation and with proper training will produce a pliancy and facility of speech to meet the requirement of the engineer. In this cultivation we dare not be so narrow as to place our cultural studies and subjects beneath the technical. It is often advanced by engineering students that the study of cultural subjects is an absurd waste of time. They have the misleading idea that correctness of form and clearness of expression are of secondary importance in the practicing field and that the exercise of such abilities is foreign to their profession. Later in the practicing field they find that, while they can marshal facts and deduce conclusions, they cannot present these deductions with clearness and force. In order to win favorable judgment it is necessary to present thoughts convincingly. In other words, 'English is not only a means for engineers to express themselves in engineering reports, but it is also a means for engineers, as members of a profession, to take their stand with members of other professions as cultured men of the world.'"

UNIVERSITY OF MISSOURI

On April 6 the University of Missouri Student Branch held a meeting at which F. A. Fraune gave a talk on Safety Engineering. The lecture was well illustrated with lantern slides.

UNIVERSITY OF NEBRASKA

Prof. J. D. Hoffman, Member American Society of Mechanical Engineers, was the speaker at the March 9 meeting of the University of Nebraska Student Branch, and he chose as his topic, the history of The American Society of Mechanical Engineers from the Beginning. He concluded with an account of the home of the Society in New York, which he illustrated with lantern slides.

On April 7 the subject of discussion was Engineering in Japan, by H. Ichinose and N. Sato. Mr. Ichinose took up the subject of railroads, giving conditions before and after their advent. He illustrated by drawings the types of locomotives used, giving their size, gage, wheel base, etc. At first nothing but American and English locomotives were used, but at present all are made in Japan. The maximum speed is about 40 miles per hour, due to the narrow 42-in. gage; the cost of building is $45,000 to $55,000 per mile. At present there are 7000 miles of railroad over an area equal to that of California. Mr. Ichinose had on exhibition several engineering books in Japanese, among them specifications for locomotives and boilers. Mr. Sato took up manufacturing and by means of lantern projections showed the curious method in which the Japanese do things: how they build bridges, canals, and how they erected their large buildings. He said that great care had to be taken on account of earthquakes. Engineering had been held back in the past on account of lack of iron ore for steel construction work, but they had taken long strides since the Russian War and the present outlook was bright. Chemical engineering was developing rapidly and would exceed all other classes in a short time.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. The published list of "men available" is made up from members of the Society. Notices are not repeated except upon special request. Names and records, however, are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. Further information will be sent upon application.

POSITIONS AVAILABLE

342 Young electrical and mechanical engineer with experience in designing of machinery and power systems for industrial service, construction and erection; must be a good calculator and have executive ability. Location, New Jersey.

401 General superintendent or factory manager for a completely equipped plant for manufacturing grinding wheels of all kinds. Requirements are experience, capacity, reliability and ingenuity. Location, New England. Name strictly confidential. Apply by letter through the Society.

402 Beginning September 1, 1914, one of the leading universities desires well-trained, experienced research assistant in mechanical engineering at salary of $1600 for 12 months' service with one month's vacation on pay. Also experienced instructor in mechaical engineering laboratory practice at salary of $1200 for ten months' service. Full statement of applicant's training and experience, together with recent photograph and list of references, is required. Location, Middle West. Apply through Society.

404 Master mechanic or mechanical engineer, between 35 and 45 years old, in Southern paper mill to take charge of mechanical equipment, operation and maintenance, also mill buildings maintenance. One who has had paper mill experience and in handling Southern white help preferred. Salary, $1800-$2000. Location, eastern Texas.

405 Designer of a line of marine type Diesel engines of from ten to forty-five horse power. Location, New Orleans, La.

406 Two draftsmen; design of railway construction dump cars. Location, New York.

409 Assistant to chief engineer in design of large hydroelectric developments. Must be familiar with all branches of this work, competent to develop designs with only general supervision. Give full record of training and experience, letters of recommendation or references, and salary desired. Location, Pennsylvania. Name confidential. Apply through the Society.

410 Superintendent of building operations, comprising considerable ferro-concrete work, furnace and other constructions. Man preferred between 35 and 55 years of age, who has had extensive experience in large factories in the heavy chemical trade and capable of carrying out details and attending to construction work. Location, Delaware.

411 Engineer, thirty years of age, experienced in production of engineering work, also practical manufacturing. Location, New York.

412 Young, aggressive man capable of managing a manufacturing proposition. Experienced in manufacturing, thoroughly dependable. Could make an investment of $25,000 or $50,000 if he should find the right party. Location, eastern Missouri.

123 Member, wishes to get in touch with a manufacturing concern that would consider manufacturing an entirely new type of automobile wheel which is more durable, more resistant and lighter than the present type of wheel, patents for which have just been applied for.

124 Technical graduate, with several years' experience, will buy an interest in consulting engineering business if earning power can be shown. Location, eastern Pennsylvania preferred.

125 Instructor in machine shop practice for large state university in Middle West. Apply through the Society.

126 American agents wanted on patent specialties for marine purposes, of concern located in Glasgow, Scotland, manufacturing filters, heaters, evaporators and distillers.

MEN AVAILABLE

E-200 Graduate engineer, 15 years' experience in connection with steam, hydraulic and compressed air machinery, wishes to associate with firm engaged in the development of new lines, with compensation arrangement consisting of a nominal salary and royalty on such patentable devices as he may work out.

E-201 Graduate mechanical engineer, age 33, married, at present employed, desires position as manager, engineer in charge, or assistant chief engineer. Wide experience in design, construction and installation of centrifugal pumps and pumping machinery. Has had charge in shop, field, drafting room and sales office.

E-202 Junior member, age 28, graduate mechanical engineer, five years' practical experience in foundry, machine, erecting, and electrical repair shops, drafting room, two and one-half years as switchboard operator on the Panama Canal Zone, desires change. Prefers position as instructor in mechanical engineering. At present employed.

E-203 Member, age 40, specialist in mechanical movements and contrivances, gearing and automatic machinery for special work, would like a position with manufacturing concern desiring a man who will make a study of their machinery and methods, suggest more efficient and economical ways of doing things, invent and design new machines or attachments, and in general improve the quality of the product and decrease costs through the introduction of better mechanical equipment. At present employed in similar capacity.

E-204 Member, nine years' experience in the teaching of mechanism, descriptive geometry, drawing, and engineering mathematics; six years' practice in mechanical engineering work; author of texts in descriptive geometry and mechanism, and articles in engineering journals, successful as teacher, lecturer and manager, desires position in university or technical school.

E-205 Member; production engineer and manager; experienced designer, organizer and producer; familiar with best methods of management, quality and speed production for machinery, metal goods and textiles. Operated under Taylor system and others. Present work completed about June 1, and applicant desires permanent connections with growing or large concern desiring to maintain with its own organization a permanent policy of efficiency and improvement.

E-206 Member, 38 years of age, desires position as superintendent or factory foreman, practical machinist, ten years' experience in charge of shops and departments; competent to organize; thoroughly familiar with all modern manufacturing methods and systems. Location immaterial. Best references.

E-207 Student member, will graduate in June with degree of M.E. from five years' course in a Middle Western university. Desires to start as an apprentice and work up in a factory which specializes in the manufacture of improved farm machinery. Experienced in all types of machinery used on southern Minnesota farms.

E-208 Mechanical and construction engineer, age 38, about to return to the United States from employment in a foreign country. Desires position as designing engineer or superintendent. Technically educated, fourteen years' experience in engineering work, twelve of which in the design, construction and operation of plants for cement manufacture and for the mining and coking of coal. Has held position as chief draftsman, mechanical engineer and superintendent of construction and operation.

E-209 Production engineer, general superintendent or mechanical engineer on manufacturing equipment, with seventeen years' experience. Good executive, with ability and experience in reduction of cost of design and manufacture. Seven years with automobile concern. Age 35; married. At present employed.

E-210 Cornell graduate, associate member, eight years' experience. Desires position as manager or superintendent, assistant or engineer of manufacturing concern or on construction work. Hydro-electric and concrete work a specialty. At present employed. Will go anywhere in United States or abroad.

E-211 Junior, university graduate, four years' experience in drafting room and office. Desires position as assistant to chief engineer or superintendent of manufacturing concern, in or near New York City.

E-212 Associate member, desires position as designing engineer, automatic machinery a specialty, or as erecting engineer. Age 40; married.

E-213 Technical graduate, married, age 32 years, with excellent executive ability. Has had five years' experience in engineering department of large corporation, four years in operating department of same company, and three years as superintendent of plant employing nearly 1000 men. Open for engagement May 1. Well fitted and thoroughly competent for position of manager or general manager of smaller company.

E-214 Junior, graduate mechanical engineer with some drafting experience, two years in charge of mechanical laboratory in a leading university of the Middle West, and at present employed. Desires change to commercial position with good prospects for the future or connection with recognized technical school. Fluent knowledge of German. Location, Eastern States.

E-215 M. I. T. graduate, with experience on instructing staff and four years' experience in efficiency engineering and scientific management in power, manufacturing and auxiliary departments. Desires further work along this line or permanent executive position with concern desiring energy and ability.

E-216 Junior, age 31, single, technical graduate in mechanical and electrical engineering. Desires to make connection with reliable firm of engineers, contractors or large industrial plant. Experiences as assistant in cotton seed oil mill, tests, eight years in design, construction and operation of high and low voltage sub-stations, selling small gas engines, city railway work. Can give best reference and willing to start at moderate salary.

E-217 Technical graduate, 31 years of age, desires position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing, purchasing, superintending construction and operating departments; consulting engineering work on large properties; power production investigations; cost reduction; experienced in mill and reinforced concrete construction work. At present employed, but desires a change for advancement.

E-218 Mechanical engineer, technical graduate, age 38, thirteen years' experience in manufacturing lines: shop, operating, drafting, engineering, efficiency, sales, including railroad, Corliss engines, gas engines and producers, saw mill, mining machinery, transmission and special machinery, complete steam and gas power plants.

E-219 Member; wide experience in machinery, metals, processes and their requirements; has filled efficiently positions from machinist to production engineer and knows the cost of production and the value of quality; accustomed to placing rigid contracts at rock bottom prices and can distinguish between low price and low cost, desires a position as purchasing agent and engineer for large establishment.

E-220 Man experienced in drafting room management in the lines of printing press and kindred machinery invites correspondence for his services. Can lead work through designing, pattern work, machinery erecting and testing.

E-221 Superintendent and expert on best machine shop practice and manufacturing methods. For the last two years engaged in selecting and installing equipment for and putting into operating condition in all details one of the most modern machine buildings and manufacturing plants; will soon complete this work. Desires position as production and manufacturing expert, superintendent or manager.

E-222 Member, age 31, married, well informed and of good address, desires change. Thorough operating and commercial experience; college training; assistant to executive, purchasing or administrative officer preferred. Salary, $4,000.

E-223 Junior member, age 29, with twelve years' experience; for past four years, mechanical engineer for large manufacturing concern; experienced in construction work, power plant design and operation, conducting boiler tests; also familiar with purchasing of engineering apparatus and materials. Desires position as mechanical engineer or assistant to manager.

E-224 Cornell graduate, mechanical and electrical engineer with thirteen years' broad experience in design, erection, operation and appraisal of public service and industrial properties, factory maintenance and operation, and sales engineering. Desires a permanent position with consulting engineers or manufacturing company in or near New York City. Appraisal engineering preferred.

E-225 Junior, age 32, engineering training and experience of ten years in engine and boiler manufacture and general plate work, desires position with growing concern. Capable of filling any responsible position in this line.

E-226 Cornell graduate, mechanical and electrical engineer, with twenty years' training and experience in designing, constructing, maintaining, operating and managing. Desires position as mechanical, electrical or efficiency engineer, superintendent or manager.

E-227 Technical graduate, age 30, eight years' experience in gas engine design and manufacture, best references, tireless worker, at present superintendent of gas engine plant, and qualified for position as superintendent, production manager or chief engineer. Would like opportunity for financial interest under agreeable circumstances.

E-228 Member, at present employed, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position; 18 years' varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; testing and general plant engineering; familiar with the handling of men, drawing up contracts, purchasing equipment and material, appraising properties; modern methods of manufacturing and marketing product.

E-229 Technical graduate 1912, two years' experience in testing department of large eastern electrical manufacturing concern, desires position in power department of public utility plant or with banking concern handling public utility properties. Location New York City or vicinity preferred.

E-230 Graduate mechanical engineer; age 29; seven years machine shop practice. Drafting experience on large power house design and with large corporation in general engineering, mill building, design, process layouts, machine design and small power house design; also machinery designing engineer. Capable of acting as assistant engineer or assistant chief draftsman.

E-231 Junior member, age 25; technical graduate in mechanical engineering; several years' broad experience as factory inspector for casualty company, and familiar with all classes of manufacturing. Best references.

E-232 Designing engineer with technical training, and shop experience, desires position with live concern in the middle west. Experienced in the design of machine tools, special machinery and tools for reducing the cost of production, presses, dies and other tools for sheet metal stamping. Can offer some patentable improvements in process for light sheet metal stamping.

E-233 Member, owner of patents for internal combustion turbine, desires partner or position where experience in this line is desirable. Has had eighteen years' experience in various engineering fields, executive and inventive ability. Location New York City or vicinity. Salary $2500 to $3000.

E-234 Graduate mechanical engineer; age 24; now employed as assistant superintendent and purchasing agent in a company making gasoline motors and other lines. Desires to get into purchasing or sales line. Has had experience in shop, and as assistant chief engineer in large engine and boiler concern.

E-235 Junior, age 28, graduate mechanical engineer, with ten years shop and office experience in design of Diesel engines, machine shops and general mill engineering. Desires position as assistant to mechanical engineer with firm that can offer something of permanent character. New York preferred.

E-236 Mechanical engineer, with ten years' experience as draftsman, designer, engineer and superintendent, in marine engines, hoisting and conveying machinery, cement machinery and plants, general manufacturing and repair work.

E-237 Sales engineer with record of accomplishment, employed in a managerial position. Seeks correspondence with progressive concerns contemplating the engagement of a technical salesman. Experience covers seven years in foreign and domestic sales. Name confidential. Address through Society.

E-238 Foundry assistant superintendent or engineer, Junior member, age 31, married. Has had 13 years' experience in shop, drawing room and foundry, last four years specializing in foundry efficiency work, installation and operation of equipment; designer of successful molding machinery, pattern mounting methods, etc.; understands melting and mixing of gray iron, malleable and crucible steel. Capable executive, organizer and investigator.

E-239 Stevens graduate, age 28, married. Experienced in general civil engineering, designing, field work in charge of the construction of municipal filtration plant. Three years inspecting fire proof building construction and manufacturing plants, four months designing special hoisting machinery. Desires to change to position that holds prospects for advancement to responsible position.

E-240 Mechanical engineer, age 30, married, with experience in design, construction and erection of steam and gas machinery; production and cost work. Two years in Brazil as head instructor in mechanical experience and consultation work on power plants. Desires position where experience will be valuable to employer.

E-241 Technically trained engineer, age 39, thorough training in machine shops, five years as engineer of steam vessels and large power plants. Master mechanic in charge of all machinery, repairs, building construction and other improvements. Past five years connected with architects' offices as mechanical engineer, designing power plants, heating, ventilating, electrical and plumbing installations for office building, factories, large schools and municipal buildings. Desires position as mechanical engineer with large industrial corporation, to take charge of power plants and equipment. Good executive, accustomed to handling men and experienced on power plant economics.

E-242 Member, age 38, technical graduate, mechanical and construction engineer, about to return to the United States from employment in a foreign country. Desires position as designing engineer or superintendent. Experienced in design, construction and operation of plants for cement manufacture, for mining and coking of coal; chief draftsman, mechanical engineer and superintendent of construction and operation.

E-243 Sales representative established in New York City desires to correspond with manufacturer to secure an additional account. A-1 standing among manufacturers, engineers and contractors.

E-244 Junior member; consulting mechanical engineer with office in Philadelphia wishes to arrange with a company in the vicinity able to use a portion of his time. Ten years' practical experience.

E-245 Technical graduate in mechanical and electrical engineering; six years' shop experience and four years as traveling salesman, desires to represent a first class company in Philadelphia or vicinity as manufacturers' agent.

E-246 Technical graduate, 37 years of age, 15 years exceptionally wide experience in teaching manual training, mathematics, drawing and machine design and mechanical engineering subjects, desires a position with broader outlook. Would accept position in a technical high school, or industrial school as director or head of department, or college.

E-247 Shop manager, specialist in interchangeable work, age 42. Experience in brass foundry. Location, New York district.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am Soc. M.E.

Die Abdampf-und Zweidruckturbinen, Karl Röder. *München, 1913.* Gift of Königl. Technischen Hochschule zu München.

American Cement Directory, 1914. *Boston, 1914.*

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The American Society of Mechanical Engineers. Journal nos. 7-12, vol. 35, 1913. *New York, 1913.*

Anleitung zur Aufstellung von Blockplänen, H. Seyberth. *Leipzig, 1914.*

De L'Apprêt des Tissus de Laine Peignée, Henri Lagache. *Paris, 1914.*

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Calcul du Béton Armé, Ch. Aubry. 2 vols. (text, tables). *Paris, 1913.*

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Jahrbuch der Gastechnik, 1912, H. Straehe.. *München, 1913.*

Main Drainage Works Proposed for New York, Geo. A. Soper. From Journal of the Boston Society of Civil Engineers, February, 1914. Gift of New York Metropolitan Sewage Commission.

Das Maschinenwesen der Preussische-hessischen Staatseisenbahnen, C. Guillery. pt. 1. *Berlin, 1914.*

Modern Filter Practice, Nicholas S. Hill, Jr. *1913.* Gift of author.

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Monthly Official Railway List, December 1913. *Chicago, 1913.*

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Preliminary Reports of the Disposal of New York's Sewage. pts. 11-16. *1914.* Gift of New York Metropolitan Sewage Commission.

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ABENDROTH & ROOT MFG. CO., *Newburgh, N. Y.* Handbook no. 41. Root spiral riveted pipe watertube boilers, exhaust heads.

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ANCHOR PACKING CO., *Philadelphia, Pa.* Cat. G, 1913.

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GOLDSCHMIDT THERMIT CO., *New York.* Reactions, vol. 7, no. 1, 1914.

GOULDS MFG. CO., *Seneca Falls, N. Y.* Cat. F. Pumps and hydraulic machinery, 1910.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.* Hess-Bright ball bearing hangers. Price list, 1914.

H. W. JOHNS-MANVILLE CO., *Cleveland, Ohio.* J-M Roofing salesman, April 1914.

KENNICOTT CO., *Chicago Heights, Ill.* Products of Kennicott.

LESCHEN, A., & SONS ROPE CO., *St. Louis, Mo.* Leschen's Hercules, April 1914.

MOREHEAD MFG. CO., *Detroit, Mich.* Morehead tilting steam traps, no. 10.

NELSON VALVE CO., *Philadelphia, Pa.* Cat. K, L, S. Bronze valves, iron body valves, steel valves.

SHADALL MFG. CO., *Wauwatosa, Wis.* Description of the aerial ventilator for both rooms.

UNDER-FEED STOKER CO., *Chicago, Ill.* Publicity magazine, March 1914.

WATERHOUSE WELDING CO., *Boston, Mass.* Welding and cutting plants.

YARNALL-WARING CO., *Philadelphia, Pa.* Description of "Lea" V-notch recording liquid meter; reducing coal consumption and increasing the efficiency of the power plant; simplex seatless valves, simplex pipe joint clamps.

UNITED ENGINEERING SOCIETY

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TRUST LEGISLATION. Hearings before the Committee on the Judiciary, House of Representatives, 63d Congress, on vols. 1-2. *Washington, 1914.* Gift of U. S. House of Representatives Committee on the Judiciary.

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OZONE PURE AIRIFIER CO., *Chicago, Ill.* Ozone (description); Ozoning the air; Loss by your office stall; What is Ozone?

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

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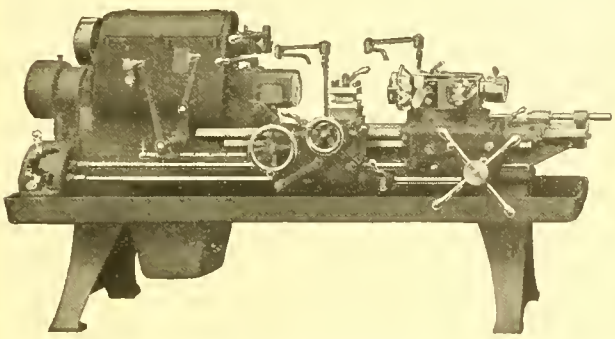

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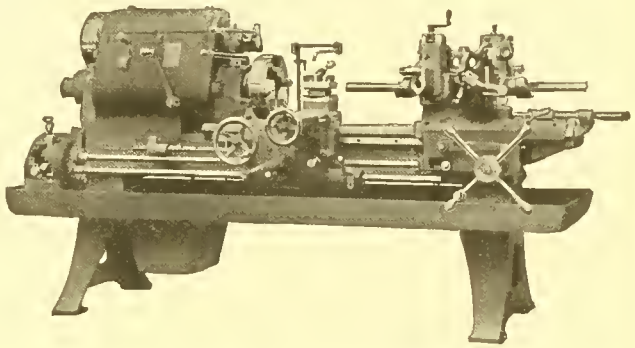

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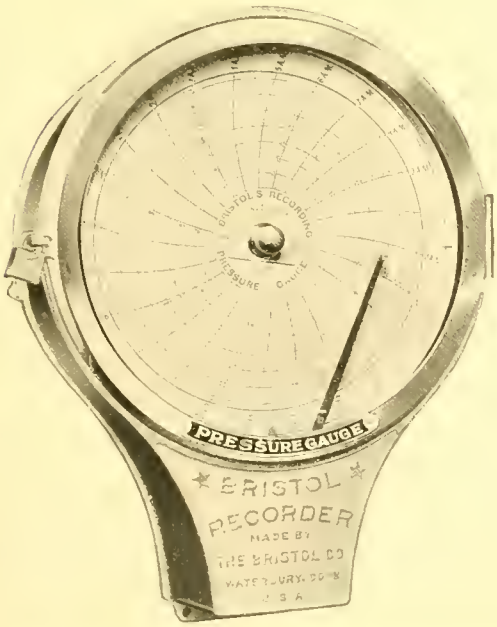

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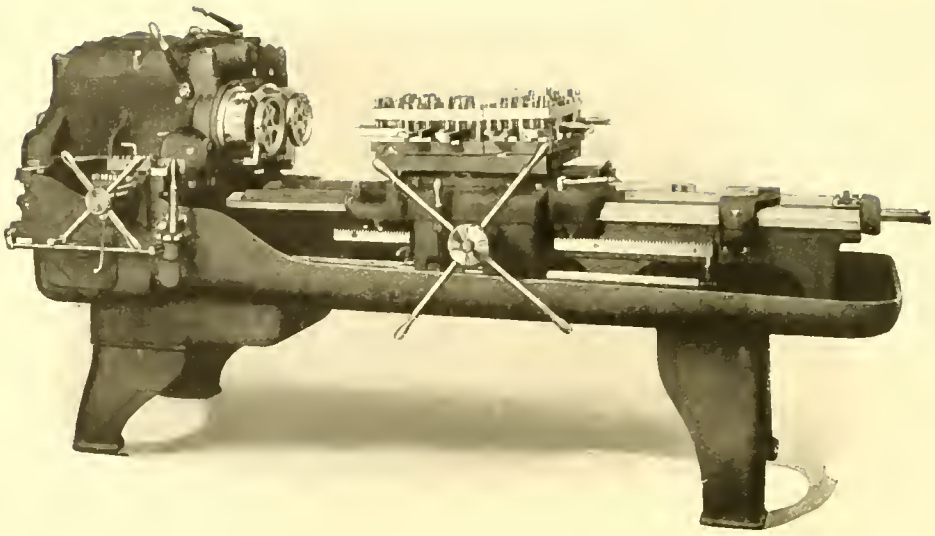

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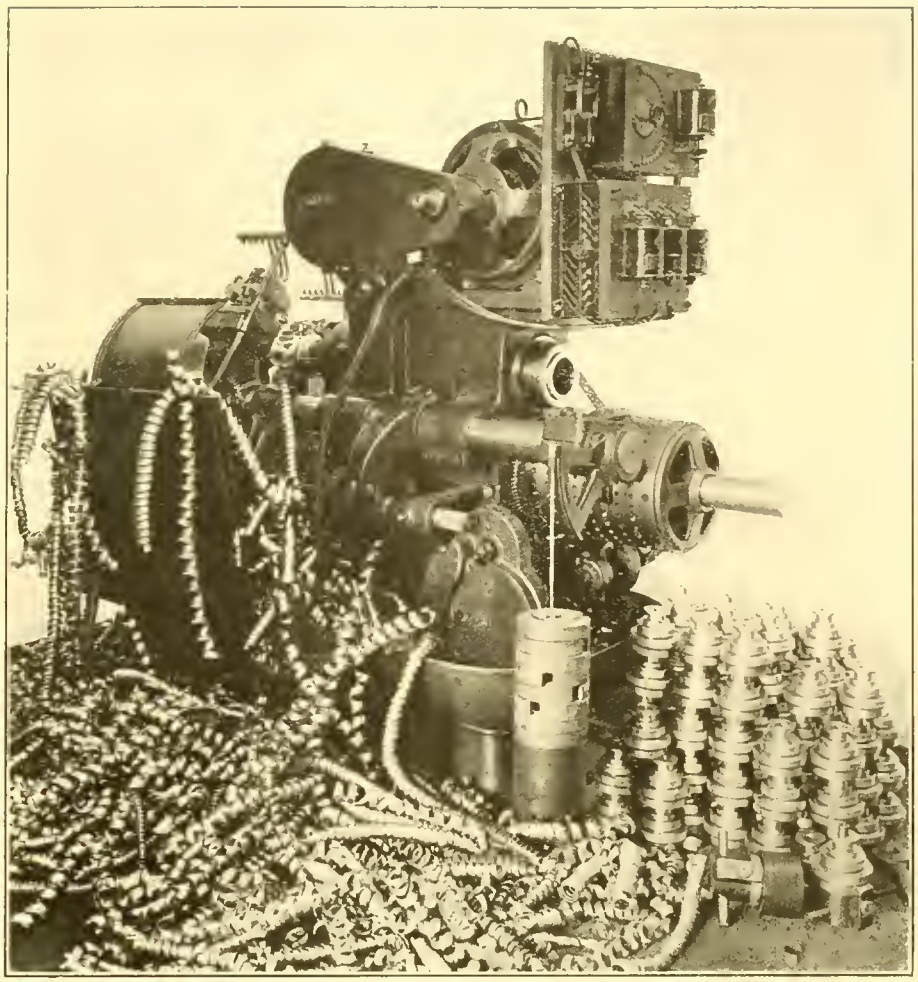


The Fay Lathe as a Stock Remover

The Fay Automatic Lathe was not designed especially for rapid reduction on a single cut, but it was designed and constructed especially for rapid reduction and accurate reduction on a number of surfaces at one time.

It is not uncommon to find a **Fay Lathe** with ten tools automatically turning and facing at one time. Bear in mind the fact that each of these tools represent a separate operation on the ordinary engine lathe and that only one operator is required for two **Fays.**

The above illustration shows the **Fay** turning out triple gear blanks from the solid and is a fair example of its chip producing qualities—but the scientific "production-man" is usually interested in figures, so here they are:

These blanks were chucked and finished on one end in a **Hartness Double Spindle Turret Lathe,** then mounted on an arbor and roughed out as shown, at the rate of 9 lbs. of stock removed in 6½ minutes. This pace was kept up in the day's run without the slightest sign of distress on the part of the machine—in fact, the strength of the arbor and the power of the motor were the limiting factors; the machine itself would have stood considerably more.

COMPANY - Springfield, Vt.

London, E. C.

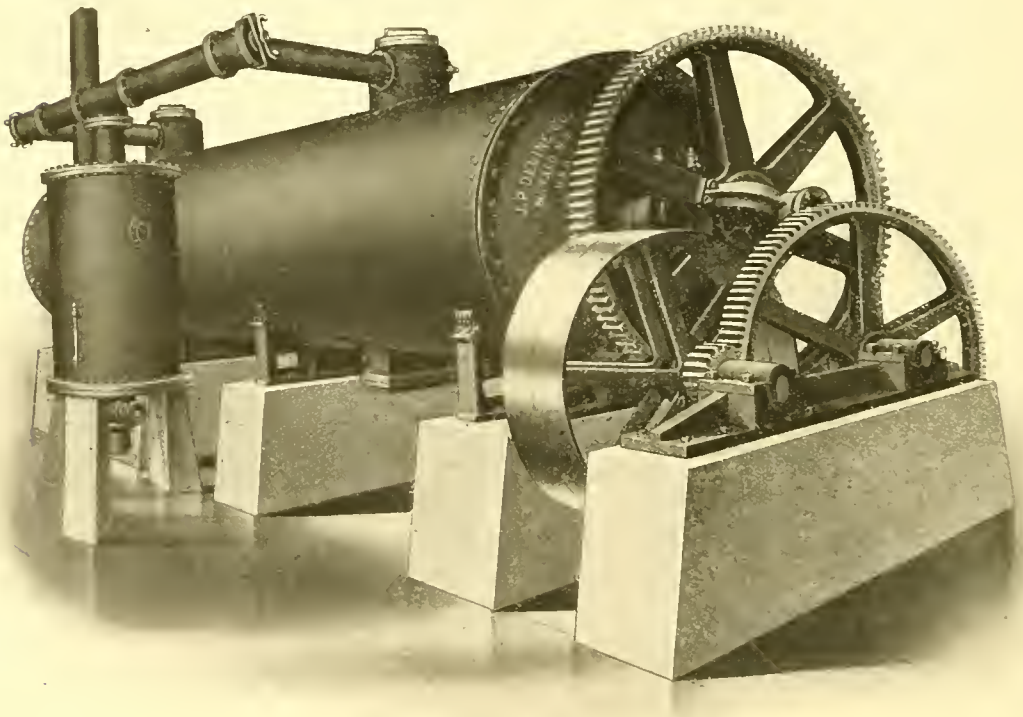
France, Spain and Belgium: F. Auberty & Co., 91 Rue de Maubeuge, Paris. Italy: W. Vogel, Milan.

Drying Problems May Confront You

Our

Vacuum Drying Apparatus

removes moisture, at lowest temperature, rapidly, thoroughly, uniformly, economically. Thirty years of experience in this one field of activity cannot help but be of value to you.



The thousands of installations in daily operation and the many repeat orders are the best evidence of our claims to be of service.

J. P. DEVINE CO.

1372 Clinton Street Buffalo, N. Y.

When planning a new station—

consider that the problem of *concentration* in the generation of power will be met (as far as the boiler room is concerned) by specification of that combustion system which will economically burn the greatest quantity of coal in the least time per unit of furnace area, namely

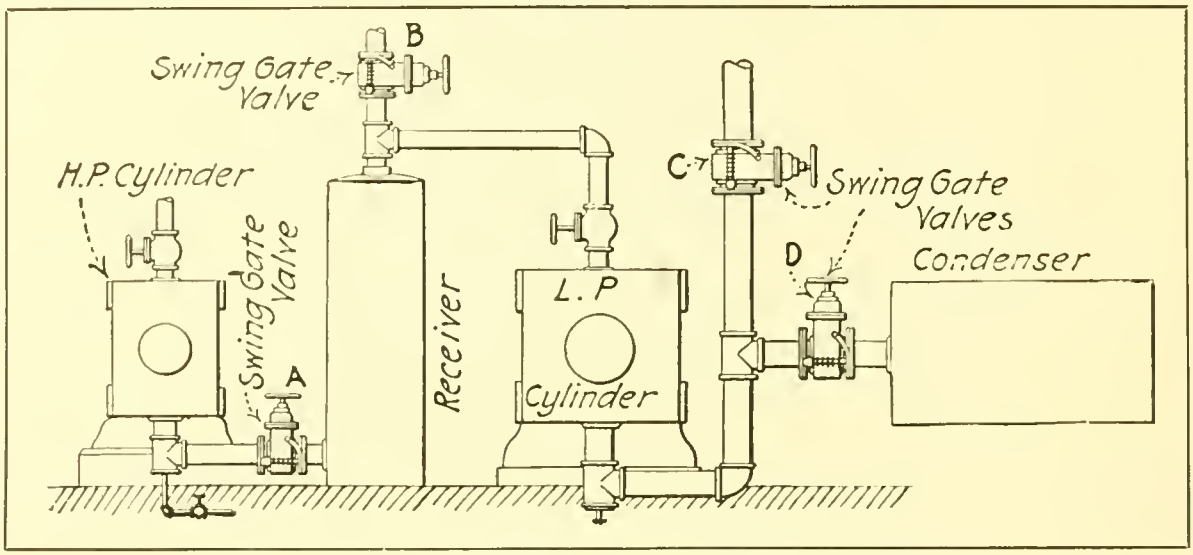
The Taylor Stoker

Consider also that THE TAYLOR STOKER meets the further internal requirement of perfect flexibility of operation, and the external requirement of the smokeless stack.

The new South Boston Station of the Boston Elevated, the Waterside Stations of the Edison in New York, the new 201st Street Station of the United Electric Light and Power Company, the Delray Station of the Detroit Edison, the new station of the Potomac Electric Power Company at Bennings, and a host of other central stations of all sizes, as well as dozens of manufactory power plants,—located both at centers of population and in isolated districts,—are working proofs of these truths.

Ask any of the companies above mentioned what their candid opinion is of THE TAYLOR STOKER. Or take the matter up with our Stoker Department

American Engineering Company
Philadelphia



Safeguarding a Compound Condensing Engine

On any pipe line where it is necessary that the flow through the pipe shall be in one direction only, and where disastrous effects follow if the medium be allowed to flow in the opposite direction, the Nelson-Erwood Swing Gate Valve is an ideal safety device presenting many points of superiority over other apparatus.

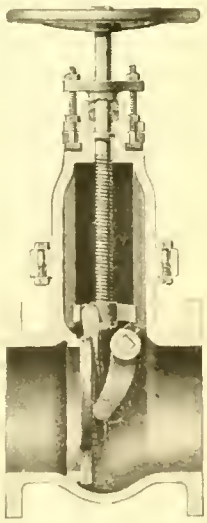
An interesting application of this valve is pictured above. With Nelson-Erwood Valves installed as shown, not only may either engine cylinder be operated singly, but they may be run together either cross-condensing or non-condensing.

The Nelson-Erwood Swing Gate Valve "A" protects the high pressure cylinder; "B" closes the receiver from the atmosphere; "C" acts as an automatic relief between condenser and low pressure cylinder, and "D" prevents water from flowing from the condenser into the low-pressure cylinder. Such an arrangement guards the engine from any possible damage through negligence in operation.

The Nelson-Erwood Swing Gate Valve

embodies the combined features of a gate, check and relief valve all in one and performs perfectly the function of all three.

Outside view showing adjustable spring, which brings any desired pressure against the swing-gate



Dotted line shows valve when pressure has exceeded spring tension.

By simply turning the handwheel, the swing gate may be taken entirely away from the current of water, steam, etc., allowing unrestricted flow, as in an ordinary gate valve.

The checking action of the swing gate is controlled from the outside of the valve.

A new circular just off press describes this remarkable valve in detail. It also contains a partial list of the big users with letters of experience from some of them.

This and any other information will be sent to you by return mail if you will drop a line today. No obligation of course.

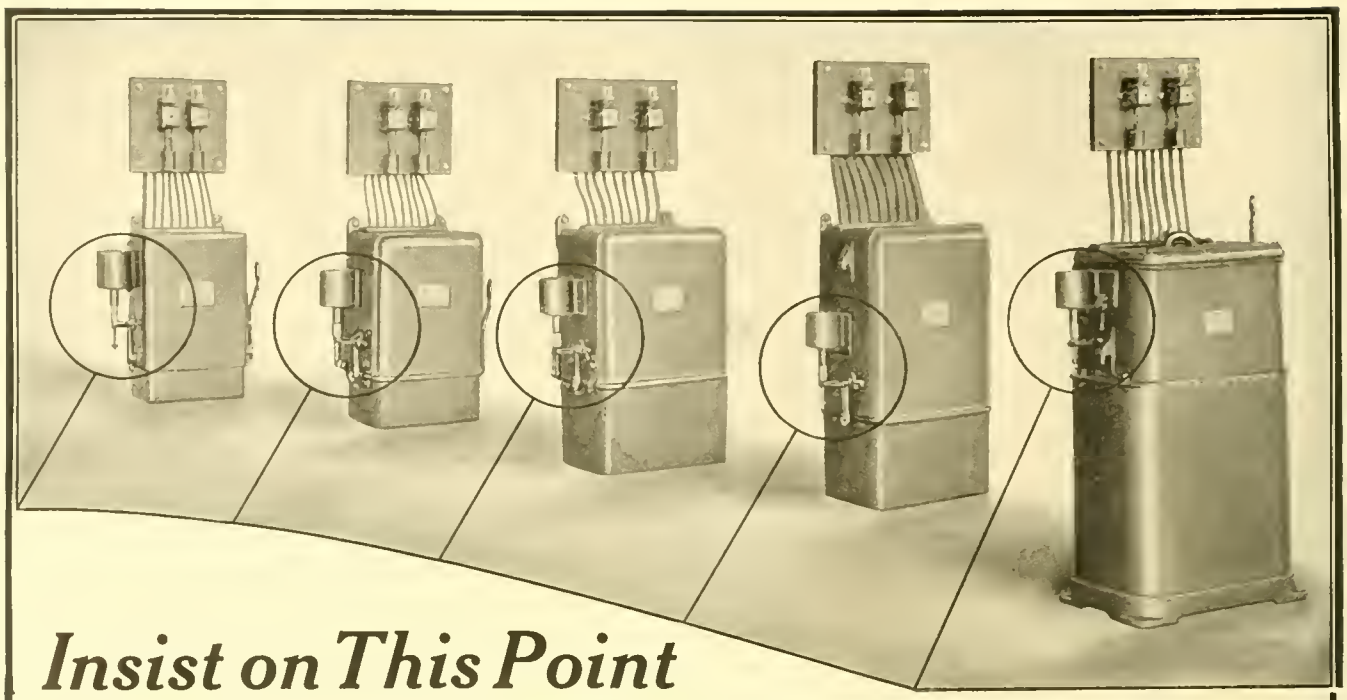
NELSON VALVE CO.

7612-20 Queen St. Chestnut Hill

PHILADELPHIA

TWO hundred million tons of coal are burned per year under power boilers in the U. S., and 5% to 10% of this, representing $20,000,000 to $40,000,000 of national resources will be saved when correct furnace design is more widely applied.

A simple and logical design is the Heine furnace with baffle tile on lowest row of tubes. If other boilers are used, direct comparison should be made to insure the same furnace volume per square foot of grate area and the same length of unchilled flame.



Insist on This Point

Specify the Low Voltage Release and get the benefits of the most modern method of controlling squirrel cage induction motors.

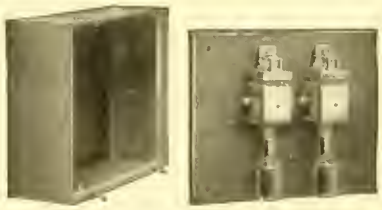
The Low Voltage Release throws the compensator to the off position whenever voltage fails.

Fuses are saved and men as well as the machines are protected because the return of voltage finds every compensator switch in the "off" position —and the motor cannot start until the operator performs the usual starting operations.

Other Advantages of the G-E Compensator

1. The handle of the CR-1034 compensator cannot be left in starting position.
2. The handle cannot be moved to running position without first going to the starting position.
3. Switches are oil immersed, thus eliminating sparking and insuring long life of contacts.
4. Compound treatment of the coils makes them practically water-proof.
5. Overload relays open the circuit in case of overload.
6. The overload relay is supplied with an enclosing cover, making the entire equipment fire-proof.

G-E Industrial Control can be furnished for the practical and economical operation of any motor anywhere.



Overload relay panels are furnished with an enclosing cover

Call, write or telephone our nearest office for further details and special information on our exchange proposition.

General Electric Company

Largest Electrical Manufacturer in the World

General Office, Schenectady, N. Y.

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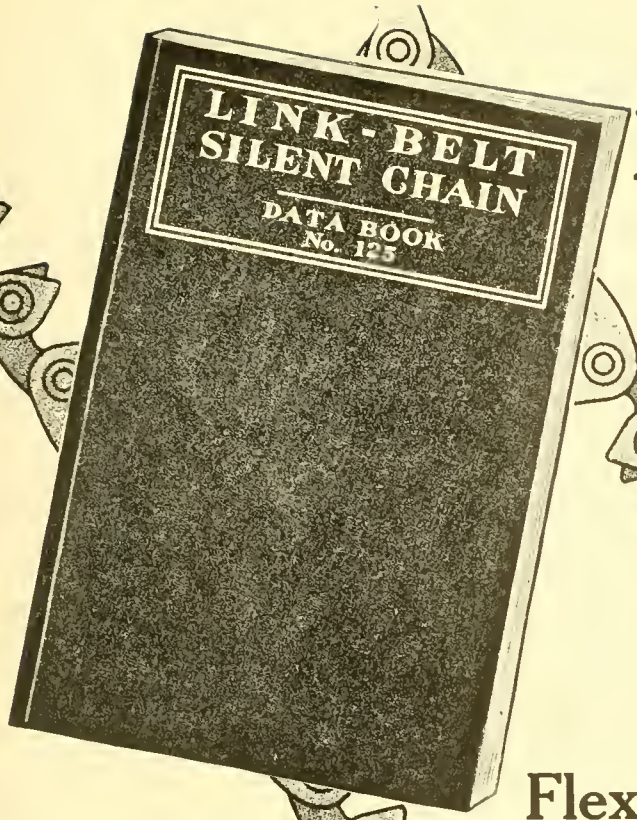
Youngstown, Ohio

For Texas, Oklaboma and Arizona business refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Lt'd, Toronto, Ont. 4450



Let This Book Be Your Authority On Chain Drives

YOU men—foremen, superintendents, managers—who have power transmission troubles—you men who demand efficiency in your shops, get this new book and study it. It is free.

It will give you a thorough working knowledge of Silent Chain as a power transmitter and will enable you to figure out readily your own Silent Chain Drives and determine their cost from the list prices and discounts.

Link-Belt Silent Chain is the modern method of transmitting power—from prime mover to machine, or from line shaft to counter shaft. It shows the highest sustained efficiency of all mediums for the transmission of power (98.2% on actual test). It is as flexible as a belt—as positive as a gear and is more efficient than either.

Flexible
As a Belt

Positive
As a Gear

Link-Belt Silent Chain Drive

More Efficient Than Either

200,000 Installations Have Been Drawn on for This Information

Link-Belt Silent Chain Data Book No. 125 is the only complete work ever published on Silent Chain. It is the result of twelve years' experience. It has cost us thousands of dollars to compile and present in an understandable way.

We desire to place a copy in the hands of every man who has to transmit power, or who is interested in the subject. Data Book No. 125 should be as valuable to the user of power as "Kent" to the mechanical engineer.

A Quick and Easy Method

of selecting drives and finding costs is given on pages 50 to 56. This is a most convenient reference for busy men to get quickly the prices of any standard motor Silent Chain Drive. No figuring necessary—simply deduct discount to obtain total cost.

This table is made up from standard speed General Electric motors, and the Silent Chains used as examples represent best practice. The drives are all figured for a minimum center distance, and a set price is given for each additional inch of center distance. Large power users will fully appreciate this short-cut table.

Data Book No. 125 contains 112 pages bound in flexible red cover, stamped in gold. Suitable for the library of our foremost engineers, as well as the small user of power transmitting equipment. Sent postpaid on request.

Link-Belt Company
39th Street & Stewart Avenue,
CHICAGO

Please send me a free copy of Link-Belt Silent Chain Data Book No. 125.

Name _____

Firm _____

Town _____

State _____

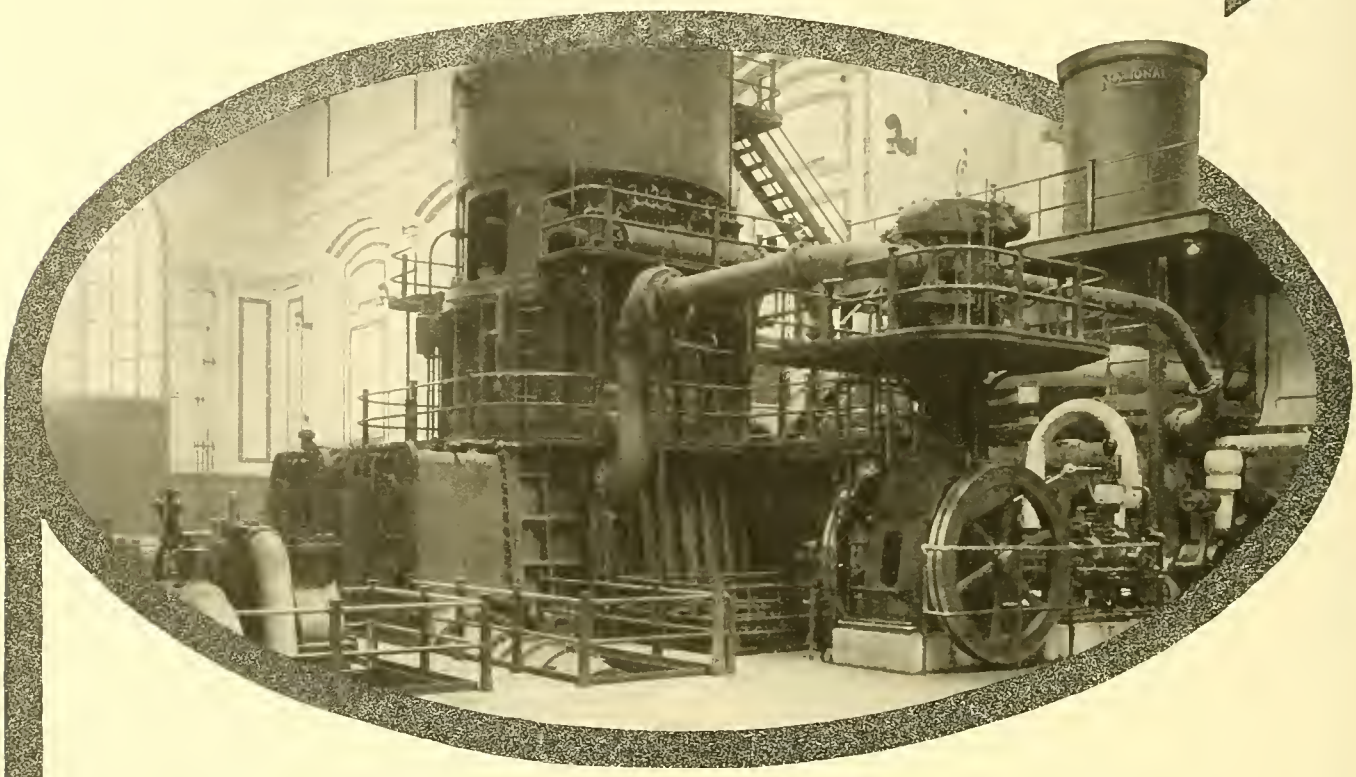
Business _____

Link-Belt Company Philadelphia Chicago Indianapolis

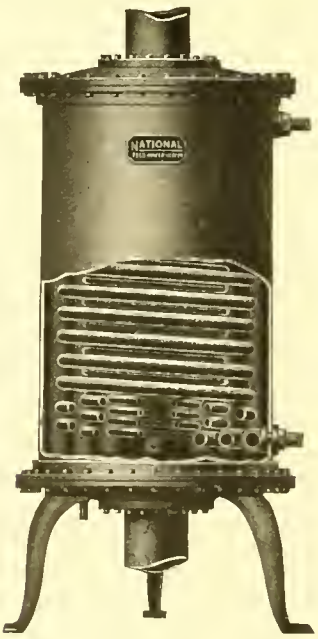
A. S. M. E. No. 1

In Power Plants such as this you find NATIONAL

FEED WATER HEATERS



In this well-known power house, with its big turbo generators, there are now in operation 40,000 Horse Power of



NATIONAL

Feed Water Heaters

To the man who selects power plant apparatus this is significant—especially when one knows that it is the business of this company to generate and sell power and that it has one of the best equipped testing departments in the world.

Because of the reputation of the Nationals previously installed, the acceptance test in this case was very simple—The National handled all the steam from the big generator when operated at maximum overload.

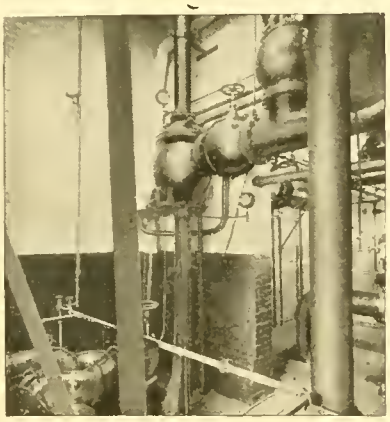
The new catalog No. 51 fully describes this feed water heater. Send for it.

The National Pipe Bending Co.

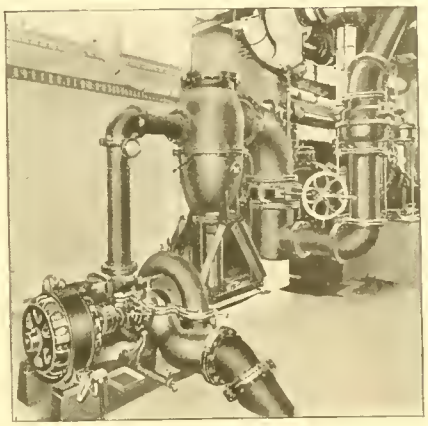
New Haven, Conn.

54 High Street, Boston 149 Broadway, New York

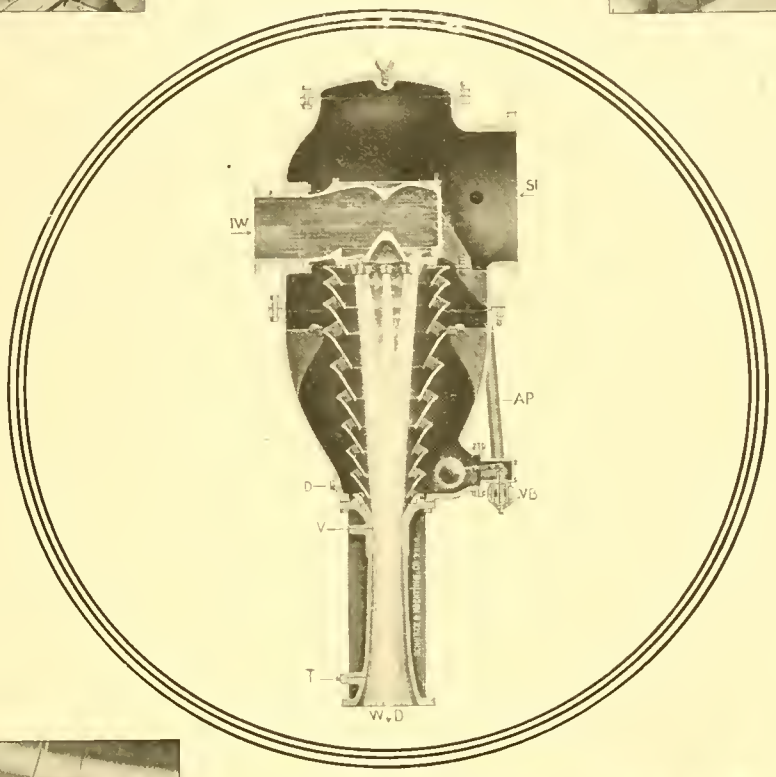
CONDENSERS



Koerting Multi-Jet



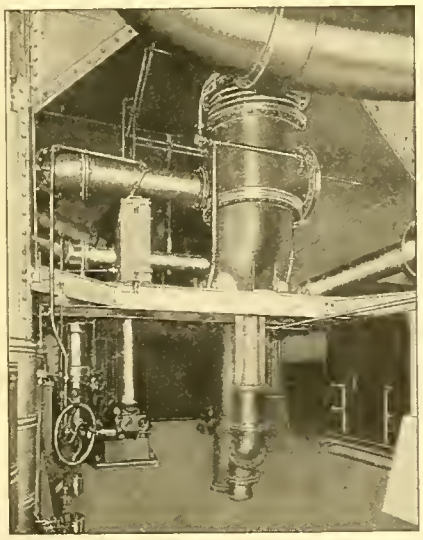
COMBINES CONDENSER and AIR PUMP IN ONE APPARATUS



THEREFORE NO SPECIAL AIR PUMP IS REQUIRED

Write for Our New Condenser Catalogue 5-AB

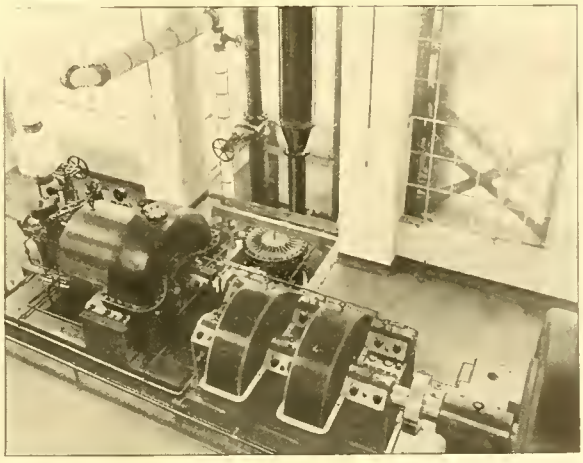
State Requirements and we will send proposition

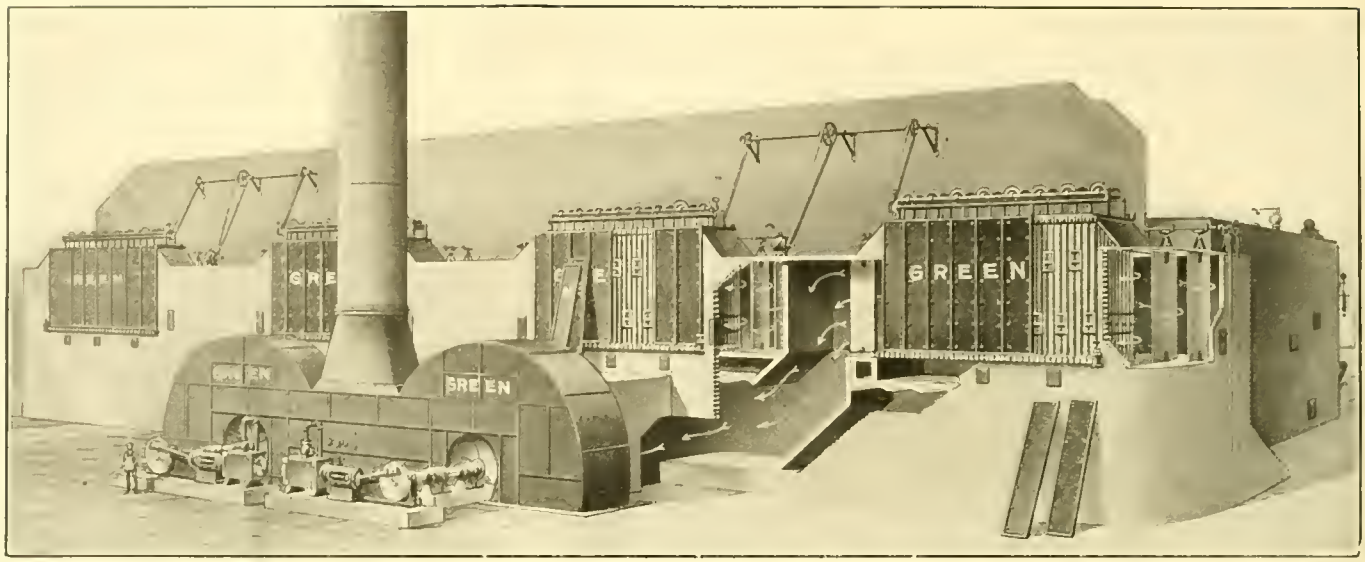


Schutte & Koerting Co.

1239-57 N. 12th St., Philadelphia

NEW YORK: 50 Church St.
BOSTON: 132 High St.
CHICAGO: Security Bldg.
PITTSBURGH: Keenan Bldg.
CLEVELAND: New England Bldg.
DENVER: 1st Nat'l Bank Bldg.
KANSAS CITY: Burton Mach'y Co.
DAYTON: Gimperling & Sons.





WHAT REPRESENTATIVE STEAM USERS SAY ABOUT

GREEN'S FUEL ECONOMIZER

Cluett, Peabody & Co., the collar makers, say:

"We are obtaining about 140° F. heat from an Economizer of 480 tubes in connection with about 1,000 boiler horse power, and we are of the opinion that our Economizer paid for itself in the very first year of its service."

Cheney Bros., silk manufacturers, say:

"Both of these Economizers have been in continuous operation since their installation, and have given us satisfactory results. The repairs have been small and the Economizers are still in excellent condition."

Johnson & Johnson, the sanitary dressing people, say:

"The water is entering the Economizer at 165° F., and the temperature when leaving is 275° F., and we are highly pleased with the efficiency of this apparatus."

The Proximity Mfg. Co., cotton mills, says:

"The fact that we have installed your Economizers in all of our plants is the best evidence that we secure satisfactory results."

The American Woolen Co., says:

"We have never had the slightest trouble and it does all that your company claims for it. In fact, I would not be without one. It has made a great saving in our coal and I can cheerfully recommend the Economizer in every way."

The Lowell Bleachery says:

"We are still using the Green's Economizer which you sold us, and same is giving entire satisfaction. In fact, it would be impossible for us to operate our present plant without it."

With fuel prices rising and economy becoming a necessity, more and more steam plant designers are coming to see the logic of **Green's Economizer.** *It is already installed in plants aggregating more than 50,000,000 horse power and over 80% of the textile mills, probably the closest figurers on economy in the world, are equipped with it. Don't wait for the economy wave to reach you. Invest in an Economizer now; it will return 40 to 60% of the first cost yearly in profit.*

Full description and explanation, valuable suggestions on steam plant design, contained in our 100-page Book M-E140.

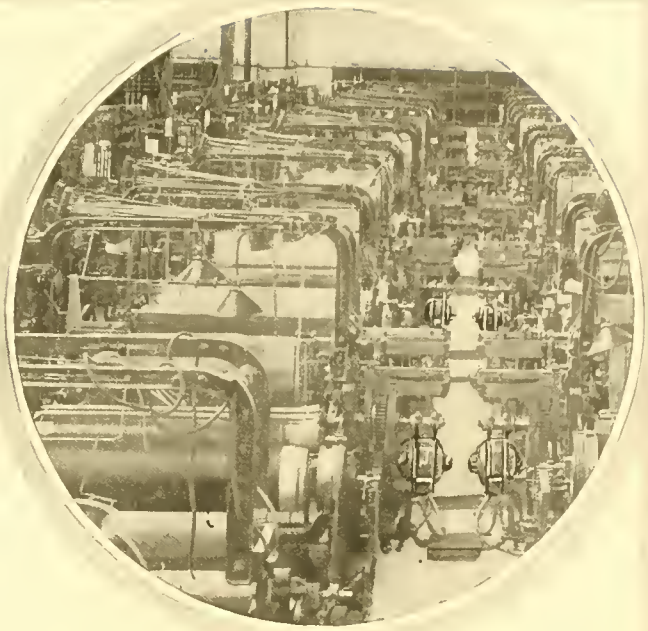
The Green Fuel Economizer Co.

Matteawan, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco
Los Angeles, Seattle, Salt Lake City, Montreal

400

MECHANICAL DRIVE



ELECTRIC DRIVE

The Most Useful Power for the Least Money--From Any Source

Comparing the mechanical lineshaft drive from engine with the G-E individual motor drive in a textile mill as shown above, brings out general truths applicable to every industry. Every man wanting more power, or desiring to pay less for power should read these comprehensive facts:

More power can be generated from a given amount of coal, over extended periods with less maintenance, by using a Curtis Steam Turbine than with any other power equipment. You get maintained efficiency without constant valve grinding and repairs due to many moving parts.

More useful power can be generated from a given amount of water, oil, sun or wind power where the power is to be conveyed any considerable distance, by G-E generators than with any other equipment. More power can be obtained at the place where it is to be used with electric transmission, if the distance is considerable than with any other form of power transmission. This is due to the high efficiency and long life of G-E generators coupled with the elimination of power losses in transmission due to steam condensation, lineshaft friction and belt slippage.

More control over power is obtained with G-E equipment than can be obtained with any other on the market today. There are more types of control equipment manufactured by the General Electric Company than by any other company in this country. These equipments provide any degree of speed variation desired immediately and with absolute certainty. The General Electric Company makes a motor for every power requirement, a controller for every motor, and has skilled engineers to combine them properly.

It will be profitable for you to consult us. The assistance of any part of our organization in solving your power problems is extended to your local power company, or our nearest motor agency.

General Electric Company

Largest Electrical Manufacturer in the World

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For Texas, Oklahoma and Arizona business refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Lt'd, Toronto, Ont. 4378

1000 Gallons of Water for 2.4c with an INGERSOLL-RAND AIR LIFT

That is the cost of pumping water at the plant of the Holts Heights Water Works, Honey Grove, Texas. This plant consists of an Ingersoll-Rand "Imperial" Type X-3 Steam Driven Air Compressor, with a piston displacement of 350 cubic feet of air per minute, installed October, 1913.

In sending us the above photograph, the dealer who installed this plant had the following comments to make:

"When we were called upon to make a test on the former installation at this plant with a view to increasing its efficiency, we found that they were operating two 12" x 12" Direct Acting Steam Driven Compressors of another make running at 140 revolutions each, steam pressure 120 lbs. The normal water level at that time was 118 feet, and the pumping level approximately 150 feet. In addition they operated two Duplex Compound Direct Acting Steam Pumps, handling the water from the surface reservoir into the standpipe. **With nut coal at $2.30 per ton they estimated their fuel cost alone to be 17½c. per 1000 gallons of water pumped.**

"Four months after the Ingersoll-Rand installation was made (Feb. 12, 1913), another test was conducted, and it was found that 413 gallons of water per minute was being discharged.

"A unique feature of this installation is that the steam cylinders were found to be of sufficient size to take care of an additional load, and consequently we attached a Triplex Power Driven Pump direct to the fly wheel of the air compressor, enabling the water company to dispense with the extravagant reciprocating steam pumps and obtain a still higher efficiency through the medium of the 'Imperial' Meyer Valve, Steam Driven compressor, operating condensing.

"The outfit operating, as described, produced 1000 gallons of water, under equal conditions of lift, into the standpipe for a fuel cost of 2.4c.

"You can readily understand why the Manager of this Institution stands with his hands in his pockets (see illustration) with a glad smile."

For Results Install an Ingersoll-Rand Air Lift

Send this advertisement for a copy of Catalog 75 on Air Lift Pumping

INGERSOLL-RAND COMPANY

NEW YORK — Offices the World Over — LONDON

AIR COMPRESSORS — CORE DRILLS — PUMPS

22-M

Materialize Your Ideas

Consult the Cowdrey Machine Works

Concerning Special Machinery

We gladly submit preliminary estimates from blue prints. Send yours to-day

C. H. Cowdrey Machine Works

FITCHBURG, MASS.

Contractors, Builders and Designers of Special Machinery

YALE

TRIPLEX BLOCK

"From-Hook-to-Hook-a-Line-of-Steel

The Yale Triplex Block and Trolley is today recognized as a universal necessity in every industry where the safe, speedy, economical handling of loads is a factor in the efficient conduct of business.

The Yale Triplex Block and Trolley is daily proving itself an important factor in *reducing production cost.* It saves the time of men and machines—with it one man is enabled to handle loads of from 100 to 20,000 pounds—and he is enabled to handle them expeditiously and safely.

Let us show you how you can use this mechanical multiplication of man-power in your plant. If you seek the newer, safer, economical way to handle your loads you will want our Book of Hoists. Write for it.

ONE HAND DOES THE WORK OF MANY

The Yale & Towne Mfg. Co.

Makers of YALE Locks, Hardware and Chain Blocks.

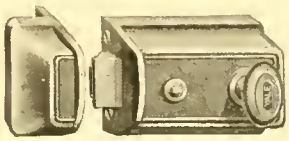
9 East 40th St., New York

CHICAGO SAN FRANCISCO

Works: Stamford, Conn., U.S.A.

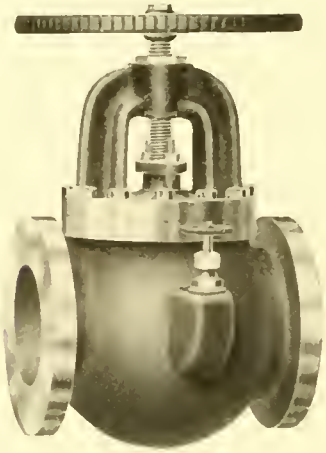
YALE

YALE Cylinder Night Latch No. 44 as here illustrated is a convenient, spring latch or a deadlocking night latch just as you *need* it. And when deadlocked it cannot be forced or picked. It will open *only* one way—and that way is with its own key. Your factory has many doors that need the Yale Night Latch—because it is a real Yale lock and that means the *best.*



Jenkins Bros. Valves

for Modern High Pressure Power Plant Service



High Pressure adds unusual wear and tear to the ordinary requirements of a valve. It is not alone important to consider what test pressure a valve will bear, but also to know under what working pressure a valve can safely be used in constant service. Jenkins Bros. Valves were very carefully designed, mindful of the importance of having every part fully capable of withstanding the severe stresses incident to high pressure service. The iron body valves as illustrated, **Jenkins Bros. Extra Heavy Globe Valves, Flanged, with By-Pass,** are guaranteed entirely suitable for working steam pressures up to 250 pounds, with an ample factor of safety, and tested up to 800 pounds hydraulic pressure. The bodies, yokes and disc holders are made of high-grade cast iron; the spindles, renewable seat rings and renewable discs of durable steam metal composition.

For *high pressure superheated steam* these valves are made with bodies and yokes of cast steel, and the spindles, seat-rings, and disc-rings of Monel Metal. The Cast Steel valves are suitable for working steam pressures up to 350 pounds, and total temperature of 800 degrees F.

Write for catalog descriptive of the complete line of Jenkins Bros. Valves and Mechanical Rubber Goods

The Diamond
Trade Mark
Is Your Protection

REG. U.S. PAT. OFF. TRADE JENKINS MARK

Jenkins Bros.

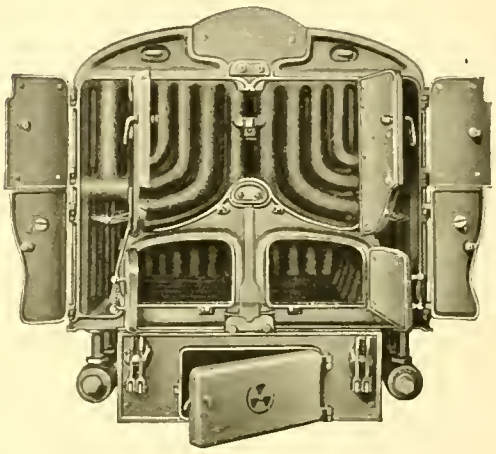
Jenkins Bros.

New York, Boston, Philadelphia, Chicago

Jenkins Bros., Limited, Montreal, P. Q., London, E. C.

Only certain boilers retain favor for years—favor of architect, contractor and user. Your client will continue to respect your judgment in specifying a

Mills Water Tube Boiler



It is so easy for you to determine the size. You know the available height—the Mills boiler catalog No. 910 will instantly give you the other dimensions when you have decided on the number of sections.

Capacity Steam rating
900 to 15,000 feet

Capacity Water rating
1,500 to 25,000 feet

Send for catalog No. 910 if you have not it handy.

56-3

THE H. B. SMITH CO.

Westfield, Mass.

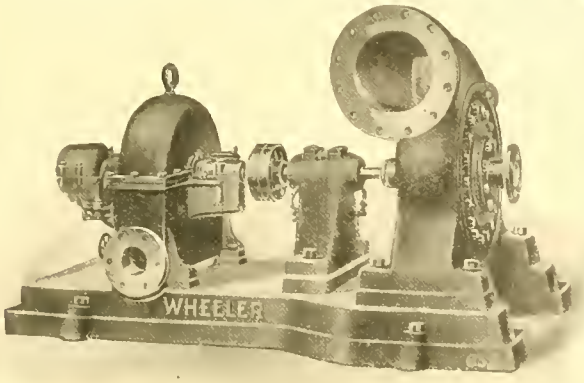
NEW YORK	PHILADELPHIA	BOSTON
39 East Houston St.	1225 Arch St.	138 Washington St.

The WHEELER TURBO-AIR PUMP

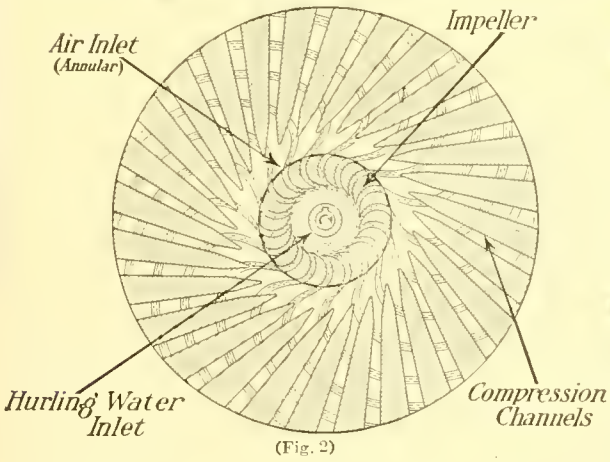
¶ Vacuums of 99% to 100%. Large Free Air Handling Capacity Insuring Maintenance of Vacuum under Excessive Air Leakage.

The Wheeler Turbo-Air Pump is a high speed rotary pump for motor or turbine drive, for use in connection with high vacuum jet and surface condensers.

For surface condenser work the air pump is combined with the hot well pump in one casing, producing a compact unit, driven by a single turbine and connected to the condenser by one pipe, through which both air and condensate are withdrawn.



The design of the Wheeler Turbo-Air Pump is based on that of the German pump manufactured by the A. E. G. and is shown diagrammatically in Fig. 2. The essential parts are a small high speed impeller in which the hurling water is accelerated and discharged in a series of jets; second, a ring of compression channels in which the air is compressed by the layers of water; and third, a casing and discharg· volute.



(Fig. 2)

The air enters around the entire periphery of the impeller and is entrapped by the layers of water at the entrance of the compression channels.

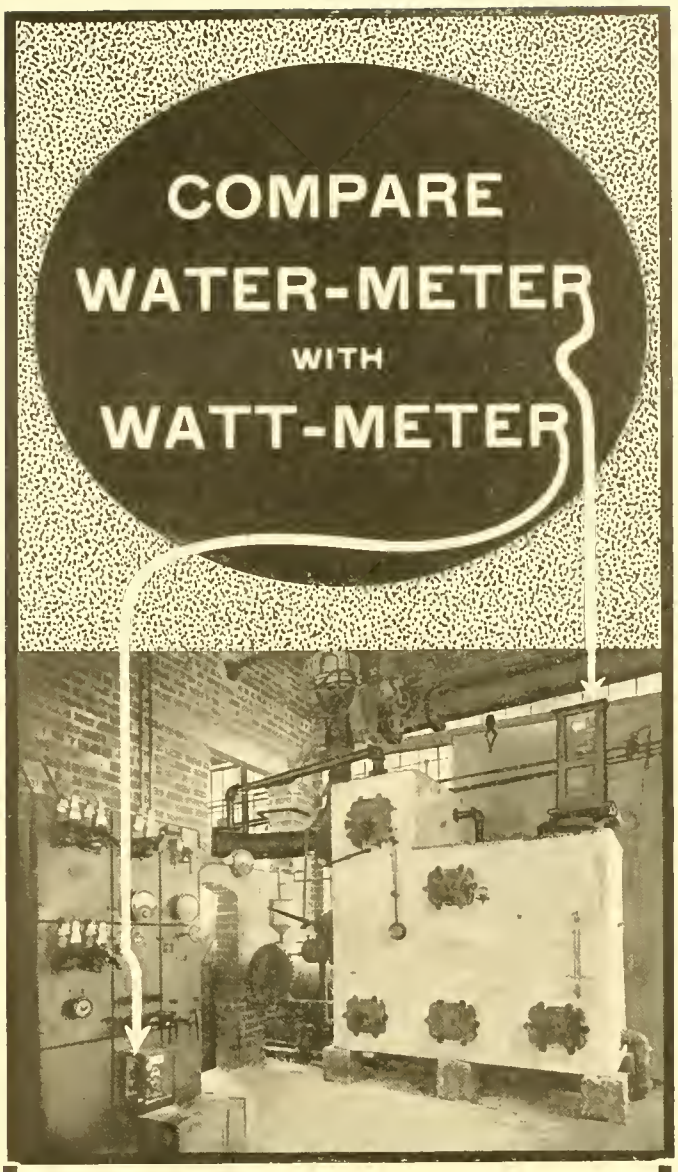
The air aspirating effect is positive, resulting in high vacuum efficiency and large free air handling capacity.

Write for our new Bulletin A 111 on Turbo-Air Pumpa, also copy of our widely used "Steam Tables for Con lenser Work."

WHEELER
CONDENSER & ENGINEERING COMPANY

The Pioneer American Condenser Builder

CARTERET, NEW JERSEY 111



THE plant shown in the photograph is so equipped that the operator can tell, almost at a glance, how many pounds of water are evaporated per KW. hour output. He can tell which is the best kind or grade of coal; whether the firemen handle the fires in the best manner; when the boiler setting needs going over for air leaks, or when the tubes need cleaning, etc. In other words, he is provided with the means necessary for maintaining high efficiency.

THE COCHRANE METERING HEATER accurately measures the water put into the boiler, and at the same time heats the boiler feed water to 210° F. or higher, depending upon the back pressure, saving 1% of coal for each 10 degrees that the water is raised in temperature.

Send for our book on "Feed Water Meters and Their Practical Application."

HARRISON SAFETY BOILER WORKS

3199 N. 17th ST. PHILADELPHIA, PA.

DE LAVAL

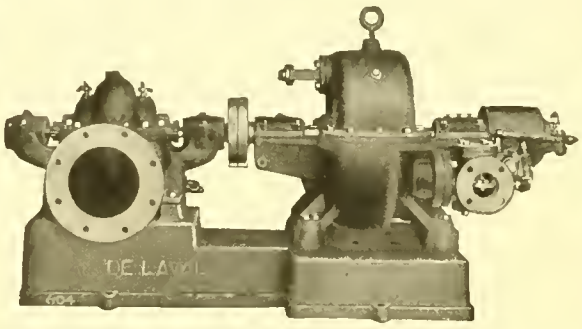
Class "C" Turbines Are Unexcelled For Driving Auxiliaries

THIS turbine is exceptionally simple in construction, the rotating parts consisting only of a shaft, two or three wheels and the governor.

ALL internal working parts are exposed upon lifting the casing cover, which can be done without disturbing the steam or exhaust connections.

AFTER removing the bearing caps the entire rotating member may be taken out of the turbine for examination or repair.

THE buckets and guide vanes are of drop-forged nickel bronze and are non-corrodible and give the longest possible life.



Class "C" Turbine Driving Two-Stage Boiler-Feed Pump

THE efficiency of these turbines is high, which coupled with their ruggedness and simplicity, makes them the ideal turbines for driving Centrifugal Pumps, Blowers, Generators, etc.

Send for Catalog C58

DE LAVAL Steam Turbine Co.

Trenton New Jersey

77B

C. H. Wheeler Condensers

We guarantee our apparatus to maintain a vacuum as close to absolute as is commercially possible, and with the lowest operating and maintenance cost.

The C. H. WHEELER "High Efficiency" System of Steam Auxiliaries includes:

- **C. H. WHEELER** High Transmission Surface Condensers.
- **C. H. WHEELER** Counter Current Central Barometric; and High Vacuum Low Level Jet Condensers.
- **C. H. WHEELER-PRATT** "ROTREX" Patent Vacuum Pumps.
- **C. H. WHEELER-MULLAN** Patent Vacuum Pumps.
- **C. H. WHEELER-THYSSEN** Hydraulic Entrainment Type High-Speed Vacuum Pumps.
- **C. H. WHEELER** IMPROVED Rotative Dry Vacuum Pumps.
- **C. H. WHEELER** Centrifugal Pumping Machinery, all capacities, Belt, Engine, Turbine or Motor driven.
- **C. H. WHEELER-PRATT** Water Cooling Apparatus, Forced and Natural Draft designs. Sold on efficiency, durability and low maintenance guarantees.
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- **C. H. WHEELER** Vertical Enclosed Self-Lubricating Engines.
- **C. H. WHEELER** Atmospheric Exhaust Valves.

Multiflex Automatic Relief Valves.
Expansion Joints.

"Everything but the Turbine"

C. H. WHEELER MANUFACTURING CO.

PHILADELPHIA, PENNA.

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RICE & SARGENT

Corliss Engines

form the equipment of a majority of the country's best Office Building, Hotel, and Department Store steam plants,

BECAUSE close attention is given even to the smallest details of design,—

BECAUSE of the close regulation required for combined elevator and lighting load,—

BECAUSE of absence of vibration, necessary in such service,—

BECAUSE of their unexcelled economy in use of steam,—

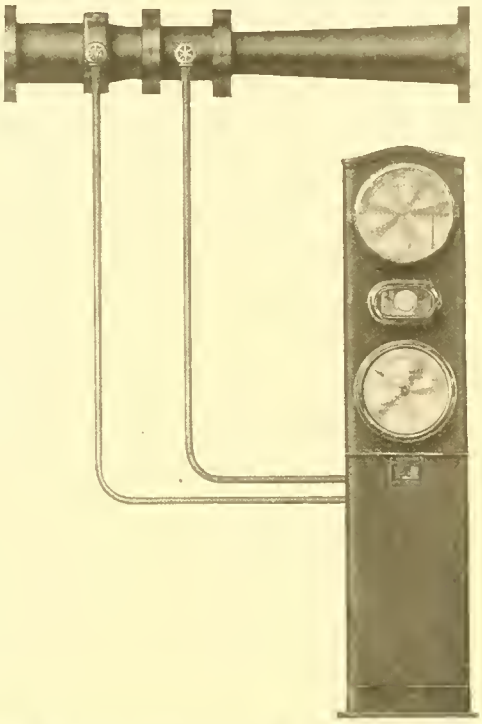
BECAUSE of their high mechanical efficiency, long life, and freedom from repairs.

PROVIDENCE ENGINEERING WORKS

Providence, R. I.

Consider the *Convenience* of the Venturi

Two steps toward higher boiler plant economy are: First, *obtain* accurate records of *present* operating conditions. Second: *Apply* the information obtained toward *improving* boiler plant economy.



A Venturi Feed Water Meter makes the first step possible—*but goes farther.*

Information not readily accessible is rarely used.

The Venturi Meter Register-Indicator-Recorder may be placed in the Engineer's office, on the fire-room floor—anywhere within 200 feet of the Meter Tube. **The latter forms a section of the feed line and may be placed either vertically or horizontally.**

The Venturi literally *brings to light* operating conditions in the boiler plant 24 hours in the day and 365 days in the year.

Ought you not at least investigate?

Bulletin No. 68 Upon Request

Builders' Iron Foundry, Providence, R. I.

"Builders of the Venturi"

NEW YORK PHILADELPHIA CHICAGO
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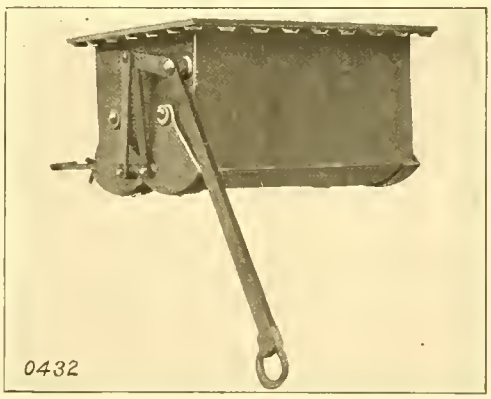
HUNT ASH PIT VALVES

ARE "WORKABLE" ALWAYS

These valves are not "Makeshifts"—they were designed for the severe service required of a "Cutoff" for the ash pit. The body is of heavy ribbed cast iron—and the jaws strong enough to break up clinker—the operating mechanism simple and powerful. The valve does not *stick*—and can be easily operated from any convenient point.



24"x 36" DUPLEX CUTOFF VALVE

Made in a number of different sizes from 8" square to the large 24"x 36" valve illustrated.

If the removal of ashes from your boiler ash pits is the sore spot in your plant write us for Catalogue S-102 and further information on the application of these cutoffs to the problem.

We also specialize in the manufacture of valves for coal, gravel, ore, sand, fertilizer materials, coke, etc.

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West New Brighton, N. Y., U.S.A.

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Try a Wattmeter on Your Line Shaft; That'll Show "Sells" Savings

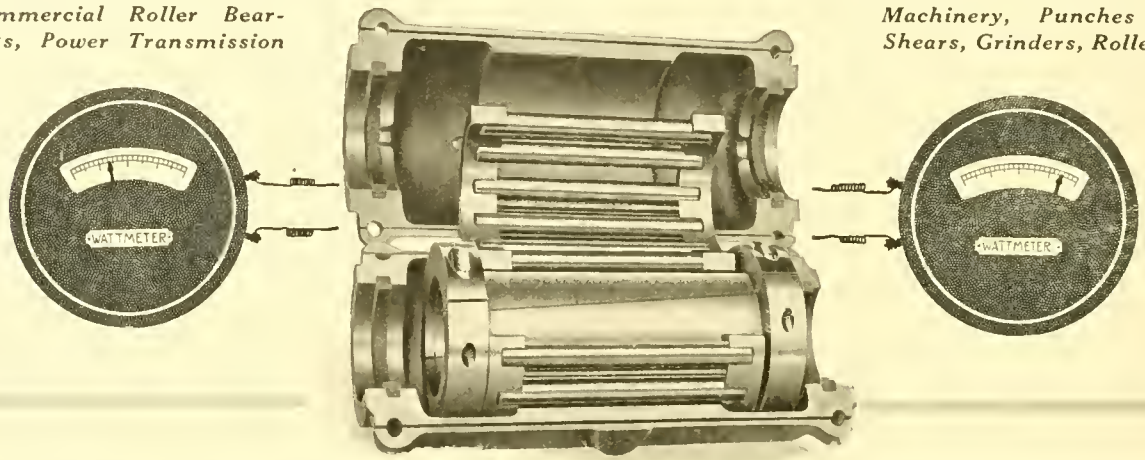
DETERMINE the wattage of your motor; then get the wattage of your motor and line shaft; the difference is the power required to rotate the shaft. Tell us what this wattage is —tell us the load on the shaft—the number and size of the plain bearings—we'll tell you how many watts will revolve the shaft if you use "Sells" Roller Bearings. At the rate you pay for current, you can figure exactly what these bearings throughout your shop would save per year. Write today for full facts on the *all-split* "Sells" and for the long list of users

"Sells" Roller Bearings

Royersford Foundry & Machine Co., 60 No. Fifth St., Phila.

Commercial Roller Bearings, Power Transmission

Machinery, Punches and Shears, Grinders, Rollerine.



WIRE ROPE

The wires in a Roebling Wire Rope are rolled and drawn from carefully selected metals and are shown by thorough and exacting tests to be strong, pliable and uniform in quality.

These wires are stranded into rope in accordance with designs and shop methods developed from the experience of many years.

Rope so made will give much more satisfactory and far more durable service than can be obtained from rope composed of lower grade wires or one in which the strands are so laid as to cause unequal stresses and uneven distribution of wear.

Improved Plough Steel Rope, made with a blue center, is recommended as the best rope for extra heavy loads.

John A. Roebling's Sons Co., Trenton, N.J.

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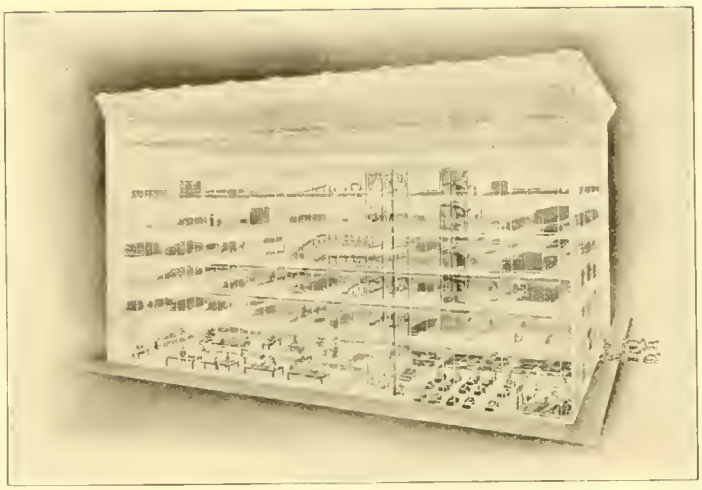
Reducing the Pay-Roll—
Improving the Product—
Increasing the Capacity—

are the three most important accomplishments of a Conveyer System.

In these days of manufacturing retrenchment, architects and engineers are alive to the necessity of providing the best and simplest means for reducing time and labor in manufacturing processes. Development in gravity and power conveying devices have attracted wide and interested attention, and all promoters of industrial projects are giving the subject thorough investigation.

Be prepared to specify the best types of mechanical handling machinery by securing literature illustrating and describing the Mathews line of Standard Equipment—the oldest and best-known in America.



Complete System of Mathews Power and Gravity Conveyers in One of the Largest Shoe Factories in the World

GRAVITY ROLLER CONVEYERS
GRAVITY WHEEL CONVEYERS
AUTOMATIC ELEVATORS
GRAVITY ROLLER SPIRALS
GRAVITY SPIRAL CHUTES
POWER PALLET CONVEYERS, Etc.

We have branch offices in all leading American cities with competent engineers in charge. Personal assistance given to architects and engineers in working out handling systems for their clients. We make no charge for this service.

ATTENTION OF MECHANICAL ENGINEERS

Cut out this coupon, attach it to your letter head and we will mail our full set of catalogs and bulletins illustrating and describing the Mathews line of Standard Equipment, consisting of Gravity Conveyers, Automatic Elevators, Gravity Roller Spirals, Gravity Spiral Chutes, etc. Sooner or later you will have use for the information given in our literature.

SPEED · MATHEWS WAY · MATHEWS GRAVITY CARRIER COMPANY · THE SAVING WAY · GOOD ECONOMY

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Runs Even—
No Edge Wear—
No Spillage—

Goodrich
LONGLIFE and MAXECON
CONVEYOR BELTS

reduce tonnage costs

The extreme flexibility characteristic of all Goodrich Conveyor Belts causes them to trough perfectly, eliminates necessity for edge-wearing idlers, and makes them run true and even, preventing spillage.

Advise us regarding your installations. We make belts for every purpose.

Goodrich Products: Conveyor Belts, Elevator Belts, Transmission Belts, Hose—All Kinds, Packing, Valves, etc.

There is nothing in Goodrich Advertising that isn't in Goodrich Goods

The B. F. Goodrich Co.
Factories: Akron, Ohio
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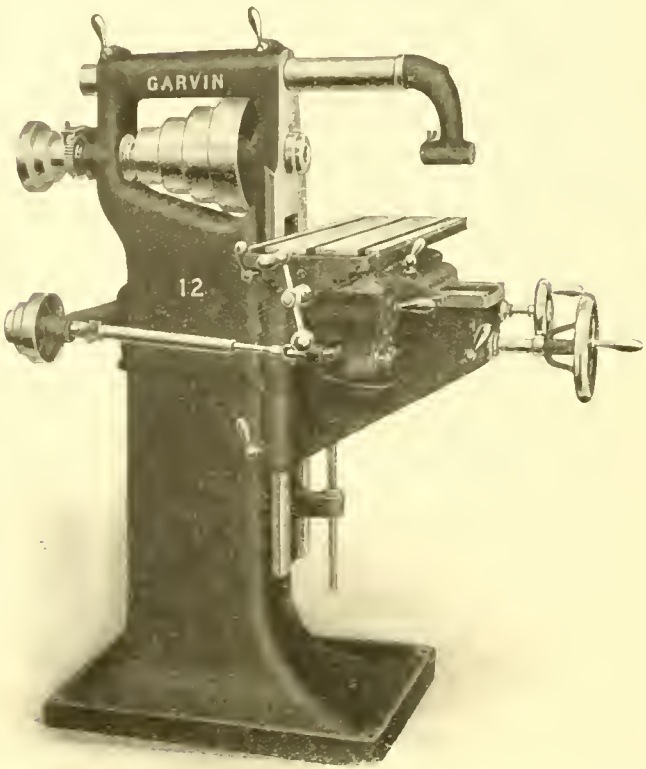
Makers of Goodrich Tires and Everything that's Best in Rubber

THE GARVIN MACHINE COMPANY



GARVIN No. 12 Plain Milling Machine
Adjustments: 18 x 6 x 15 in. Use Code—Abrade

Manufacturers of
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Numerous Styles and Sizes
SCREW MACHINES
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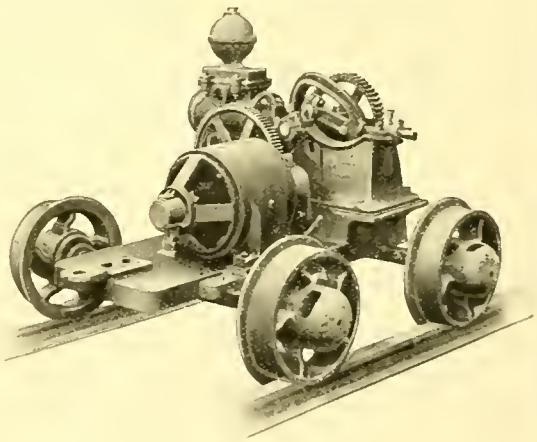
DUPLEX HORIZONTAL DRILLS
HAND LATHES
SPRING COILERS
and
SPECIAL MACHINERY

OFFICE AND WORKS
137 VARICK ST.
NEW YORK CITY

Visitors Welcome

FAIRMONT ELECTRIC MINE PUMP



The No. 1 *Fairmont Pump* makes an ideal arrangement for mine use. The equipment is compact and designed for easy handling in the mines. The sub-base is made solid cast iron grooved to set on mine car axles for moving from place to place as desired. It is easier to handle than an empty mine car. The over-all height mounted on 18″ wheels is 3′ 7″. Total weight, exclusive of wheels and axles, 1200 lbs.

Capacity 30 to 60 gallons per minute.
(local conditions governing)
Suction 2½ inches. Discharge 2 inches.

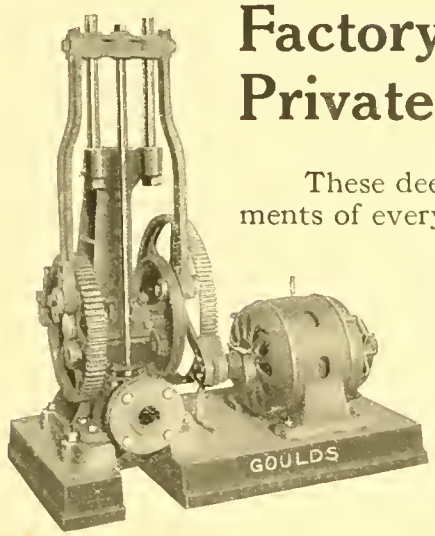
Over 300 in use by one Company

Write for our Bulletin No. 13 and prices. You will be surprised at the low costs.

Fairmont Mining Machinery Co.

Fairmont, West Va.

Goulds Deep Well Working Heads Enable the Factory or Power Plant to Have a Private Water Supply at Low Cost



These deep well pumps are made in capacities to suit the requirements of every plant and for wells of any ordinary depth.

They are furnished for belt drive or for direct-connection to electric motors, gas engines or other drivers.

The Goulds Line includes large capacity triplex deep well pumps for operation in open wells and working heads for operating single or double-acting artesian cylinders in drilled wells.

Bulletins Nos. 107 and 108 give specifications on the complete line.

Ask for copies.

THE GOULDS MFG. CO.

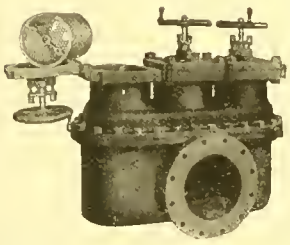
LARGEST MFR. OF PUMPS FOR EVERY SERVICE

GOULDS PUMPS

78 W. FALL ST., SENECA FALLS, N. Y.

BRANCHES AND AGENCIES IN PRINCIPAL CITIES

Power Plant Necessities



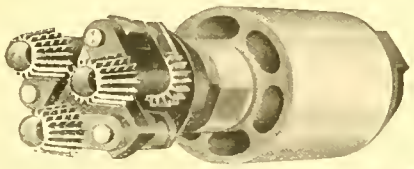
STRAINER

The Lagonda Water Strainer removes sticks, leaves, fish, etc., from power plant intake lines. It protects pumps, condensers and boilers. Can be cleaned without interrupting the flow of water a single instant.

Ask for Catalog R-1

The Weinland Turbine Cleaner back of a Weinland Quick Repair Head is best suited to ordinary boiler conditions and removes scale from tubes in the shortest possible time and with a minimum amount of water. We also make similar cleaners that can be driven by steam or compressed air.

Ask for Bulletins L and Y



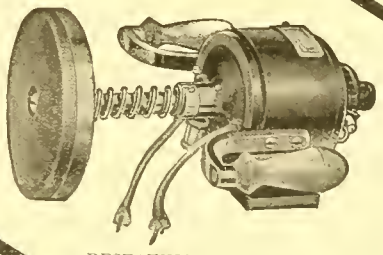
WEINLAND TURBINE CLEANER

Lagonda Reseating Machine cleans the faces, caps and nuts of B. & W. and similar boilers 16 times as fast as can be done by hand. The emery wheel is driven by either an electric, steam or air motor.

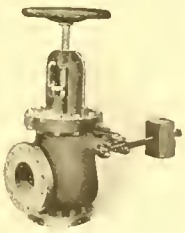
Ask for Bulletin G-1

Lagonda Automatic Cut-Off Valve closes automatically and prevents injury to employees, and forestalls costly shut-downs of plant should a break occur anywhere in a boiler tube or in the steam line.

Ask for Bulletin entitled "The Lagonda Automatic Cut-Off Valve."



RESEATING MACHINE



CUT-OFF VALVE

The Lagonda Mfg. Co.

SPRINGFIELD, OHIO

FUEL SAVING SPECIALISTS

NEW YORK, BOSTON, PHILADELPHIA, ST LOUIS, CHICAGO, DETROIT, DALLAS, SAN FRANCISCO, ST. PAUL, MONTREAL, LONDON

Makers of Weinland Boiler Tube Cleaners, Automatic Cut-Off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers

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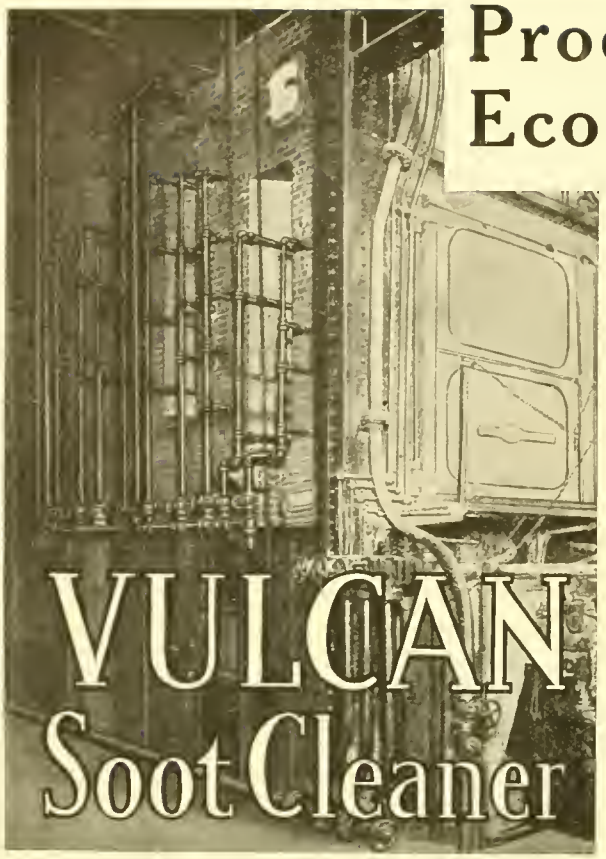


As applied to B. & W. Boilers at C. & N. W. R. R., Chicago

Produce Your Steam Economically——

The saving of coal
The saving of labor
The saving of valuable floor space
The elimination of wear and tear on men
The prevention of cold air entering boilers
The prevention of loss occasioned by idle boilers
The securing of greater boiler capacity—

all depend on the elimination of soot

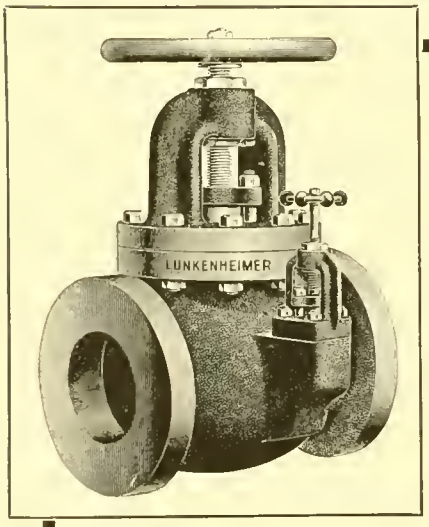
The *VULCAN SOOT CLEANER* has already made good as the *one* cleaner which removes *all* the soot, cleans all types of boilers, keeping the boiler continually soot-free. The Chicago and North Western R. R. have 109 in use. The Edison Illuminating Co., Detroit, have purchased over 60 Vulcan Cleaners in the last 7 years. The Cleveland Elec. Illuminating Co. have ordered 45 Cleaners. The N. Y. Edison Co. have installed 32 Vulcan Cleaners, and the Duquesne Lighting Co., of Pittsburg, have ordered 20.

Our catalog, "Economical Steam Production," contains valuable engineering data never before published. Every Mechanical Man interested in Fuel Economy should read this book and file it for future reference. Free copy on request.

G. L. SIMONDS & CO.

Sales Dept., 228 So. La Salle Street, Chicago

Manufactured by Vulcan Soot Cleaner Co., Du Bois, Pa.



A MOST COMPLETE LINE

of high grade Iron Body Valves, consisting of Globe, Angle and Cross; Horizontal, Angle and Swing Check; Gate, Blow-off, Pop Safety and Relief; Non-return Safety Boiler Stop, etc. Made in standard sizes and in a number of weights, the heaviest being for steam working pressures up to 250 pounds per square inch.

LUNKENHEIMER IRON BODY VALVES

are exceptionally durable and strong. The iron used was formulated in the Lunkenheimer laboratories, and has a tensile strength of 25,000 pounds per square inch.

All parts subjected to wear are renewable and are made of a high grade bronze composition, such as will safely withstand long and severe usage.

For hard service and superheated steam, these valves can be had made of **"Puddled" Semi-steel,** having a tensile strength of 35,000 pounds per square inch, or for extreme conditions of service, pressure and superheat, they are made of **Cast Steel,** the tensile strength of which is about 80,000 pounds per square inch.

Specify and Insist upon securing genuine **Lunkenheimer make.** Do not accept substitutes, —they are never as good as the genuine.

Your local dealer can furnish them; if not, write us.

A thorough description, with illustrations, is given in Lunkenheimer Catalogue No. 50. If you haven't a copy, write for one now.

13-49

THE LUNKENHEIMER CO.

"QUALITY"

Largest Manufacturers of High Grade Engineering Specialties in the World

Executive Offices and Factories:
CINCINNATI, OHIO, U. S. A.

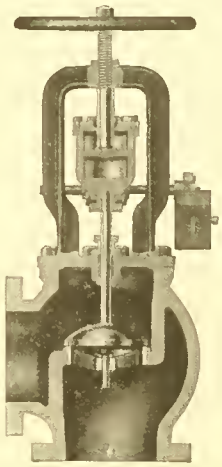
New York, 64-68 Fulton St. | Chicago, 188 N. Dearborn St. | Boston, 138 High St. | London, S. E., 35 Great Dover St.

Consider Well These Features of the Davis Class C Before You Decide Upon the Type of Stop and Check Valve That You Are Going to Use

Service—It will prevent a reverse flow of steam in case of an internal rupture to any one of the boilers in the battery. It isolates any boiler that is not up to the average header pressure.

Dependability—It will not stick. It has an outside oil dash pot. Scale formation or expansion of the parts cannot interfere with its operation.

Indicator—The counter-weight lever moves in unison with the disc. The action of the valve is always visible.



Globe and Angle Patterns

Noiseless—The oil dash pot is effective no matter how small the movement of the disc may be. It cannot pound.

Test—The condition of the internal parts can be easily determined at any time. The counter-weight lever affords means of testing by hand.

Maintenance—The disc and seat may be reground and both are renewable. The stem is packed at the factory with long lived metallic packing.

Send for Descriptive Booklet and List of Users

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Boston
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G. M. Davis Regulator Company
439 Milwaukee Avenue, Chicago

Pittsburg
St. Louis
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Manufacturers of Valve Specialties Since 1875

FULTON
Oil and Steam Engines

Are Backed by Our Reputation for Reliability "Sixty Years of Successful Manufacturing"

We build our machinery complete in our own plant. Long experience has demonstrated the proper materials to be used in our castings and our workmanship is of the highest class.

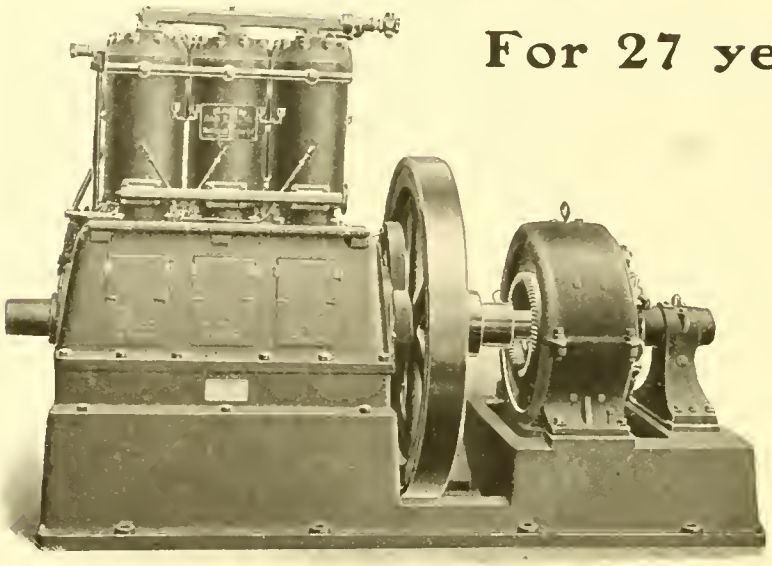
Fulton-Tosi Oil Engines, Diesel Type
Fulton-Corliss, Medium and High Speed Engines

Write for Oil Engine Bulletin "A."

FULTON IRON WORKS

1259 Delaware **ST. LOUIS, MO.**

THE NASH ENGINE



For 27 years the leader in Vertical Gas Engine Design

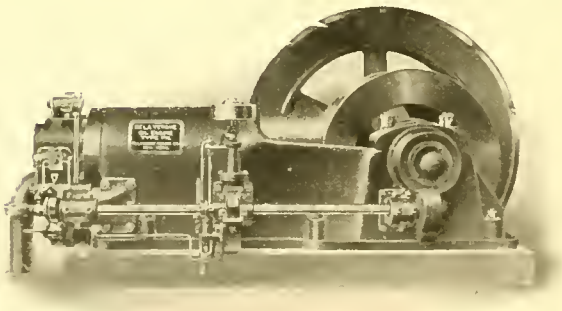
Specially adapted for

Electric Generation
Water Works
and high grade
Power Plants

NATIONAL METER COMPANY

CHICAGO NEW YORK BOSTON

De La Vergne Oil Engines



TYPE FH OIL ENGINE

Send for Bulletin No. 132

Have been developed over a period of twenty years in the United States to meet American conditions.

Heavy Mexican crude oil with sulphur up to 3½% is the cheap American fuel.

Specially trained operating engineers are expensive. The De La Vergne engine has been highly developed and will burn this cheap fuel and operate with only ordinary attention.

We guarantee when operating at three-quarters or full load a fuel consumption of one-half pound ($\frac{1}{16}$ of a gallon) per Brake Horse Power Hour of any commercial fuel or crude oil produced in the United States or Mexico.

The economy, the ability to burn the heaviest fuels and the simplicity of the De La Vergne engine make it the ideal source of power for factory service, electric installations, ice plants and isolated stations of every description.

We build engines from 12 to 800 H. P.

As many as eight successive orders comprising forty-two engines in all, have been placed by a single customer for his own use—proof positive of satisfactory service.

De La Vergne Machine Company

1123 E. 138th Street New York City

AIR COMPRESSORS AND GAS COMPRESSORS

EQUIPPED WITH

MESTA AUTOMATIC PLATE VALVES

(IVERSEN PATENT)

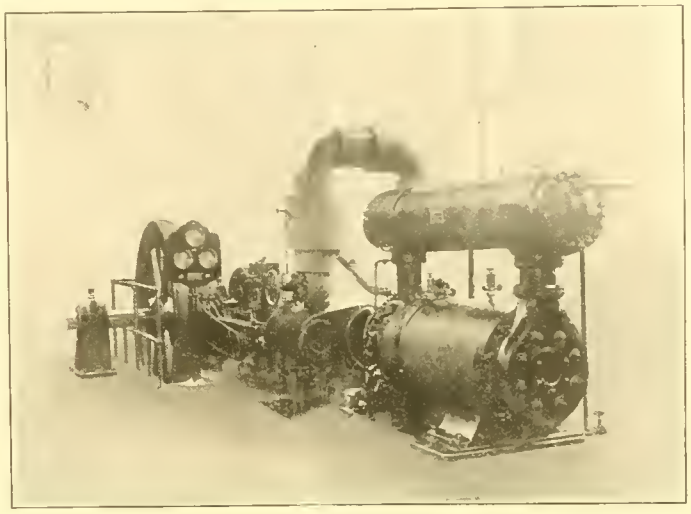
NO VALVE GEAR ——

—— NO ADJUSTMENTS

MESTA AUTOMATIC PLATE VALVES (IVERSEN PATENT) MAKE POSSIBLE MUCH HIGHER PISTON SPEEDS THAN WERE HERETOFORE USED. THEY DO IT WITH INCREASED ECONOMY AND RELIABILITY.

THE MESTA MACHINE COMPANY IS EQUIPPING EXISTING COMPRESSORS OF VARIOUS MAKES WITH AUTOMATIC PLATE VALVES OR WITH NEW AIR HEADS CONTAINING THEM.

Write for Bulletin "N"



MESTA MACHINE COMPANY

PITTSBURGH, PA., U. S. A.

WORKS: MESTA STATION, P. R. R., WEST HOMESTEAD, PA.

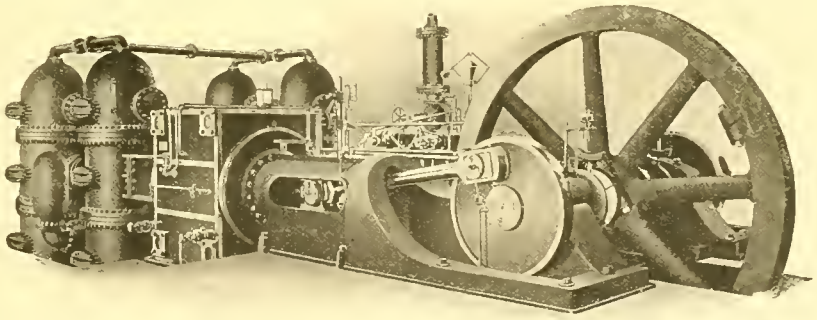
DESIGNERS AND BUILDERS OF

GAS AND STEAM ENGINES, ROLLING MILL MACHINERY, FORGING PRESSES, CONDENSERS

HAMILTON CORLISS

Horizontal Crank and Fly Wheel Pumping Engines

are particularly designed for hard service and long life and the valves are arranged in the annealed steel casting decks in such manner that the flow of water is not deflected in all directions, as is necessarily the case when the bee-hive or cage system is used.



Hamilton Corliss Engines are the most economical steam operated prime movers known and are sold on their operating record.

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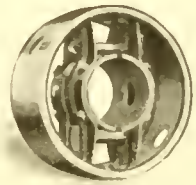
THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO, U. S. A.

A Pulley for Every Purpose



"Patented"

Design used in diameters of 3", 4" and 5".

"AMERICAN" STEEL SPLIT PULLEYS

(Made in diameters 3" to 60" inclusive)

Their superior belt grip and strength, combined with lightness, have made them the most widely used metal pulley in this country.

Dealers Everywhere

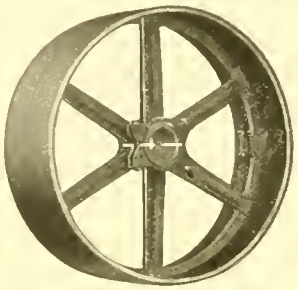
The American Pulley Company

Office and Works, Philadelphia, Pa.

New York: Cor. Grand & Greene Sts. Chicago: 124 Clinton St. Boston: 165 Pearl St.

"Patented"

Design used in diameters 44" to 60" inclusive with faces wider than 16".



"Patented"

Design used in diameters 6" to 24" inclusive.

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Design used in diameters 25" to 42" inclusive.

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Design used in diameters 44" to 60" inclusive with faces narrower than 16".

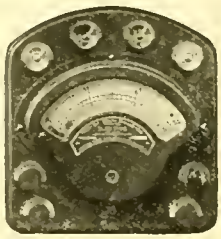
WESTON

Miniature Precision Instruments for Direct Current

A new group of very small indicating instruments

COMPACT — ACCURATE — DURABLE — BEAUTIFUL

MODEL 280, Single Range Portable Voltmeter. (One-quarter Size.)



MODEL 280, Triple Range Portable Volt-Ammeter. (One-quarter Size.)

PORTABLE

Voltmeters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters, are supplied in single, double and triple ranges.

The triple range volt-ammeter comprising six instruments in one. This group also includes BATTERY TESTERS.

SWITCHBOARD

Voltmeters Volt-Ammeters Ammeters Mil-Ammeters

This new line of instruments represents the latest development of the pivoted moving coil, permanent magnet type for low ranges.

The refinement of design and mechanical work in them has been carried to a degree which would appear to be almost impossible of accomplishment, if the results were not evident in the instruments themselves.

They embody characteristics which have made the well known Weston Standards famous throughout the world.

They are accurate, dead beat and extremely sensitive.

They may be left continuously in circuit at full load without injury and are shielded against the external electrical and magnetic influences of other apparatus in their vicinity.

They are substantially constructed and may be safely sent long distances through the mails and will withstand an extraordinary amount of vibration without injury.

MODEL 267, Switchboard Ammeter. (One-quarter Size)

MODEL 268, Switchboard Volt-Ammeter. Reads Amperes. Press Button for Volts. (One-quarter Size.)

They have the longest scale ever provided in instruments with equal length of pointer.

Each model has been thoroughly tested under the most severe conditions of service and in experiments extending over more than one year.

The portable instruments may be conveniently carried in the coat pocket.

The prices have been established upon so low a scale that any one may possess one or more of these remarkable instruments at moderate cost.

If you cannot obtain the instruments desired from your dealer, write us.

The several models and ranges offer a selection from over 300 different combinations, listed in Bulletin No. 8. Will be mailed upon request.

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I. P. MORRIS COMPANY

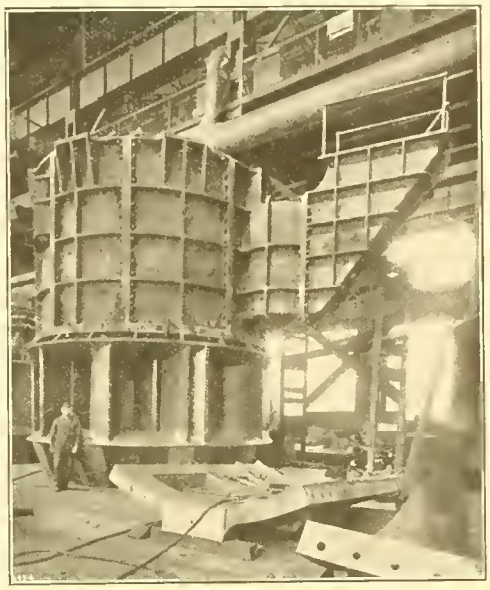
PHILADELPHIA, PA.

Specialists in the Design and Construction of High Class, High Power, and High Efficiency Hydraulic Turbines

Illustration shows one of six turbines designed and built for the Laurentide Company Ltd., Grand Mere, P. Q., Canada. Unit is of the single runner, vertical shaft type, with cast iron pit liner. Volute casing and draft tube are formed in the concrete.

The I. P. Morris Company have built or have under construction turbines of this type aggregating 472,700 horse-power.

Inquiries for turbines requiring special design will be given every attention.



20,000 H. P. TURBINE
Head 76 feet. Speed 120 R. P. M.
Most powerful Turbines of this Type ever built

R. D. WOOD & CO.

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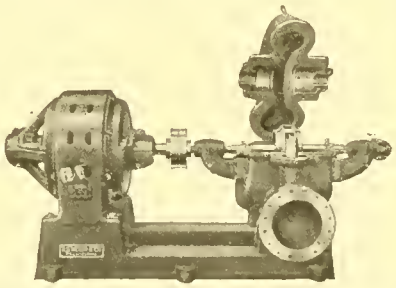
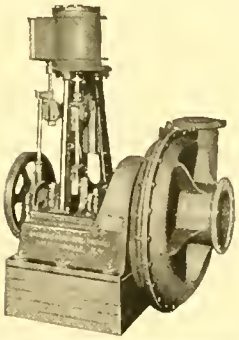
BUILDERS OF Gas Holders, Single and Multiple Lift; Gas Plants; Gas Producer Power Plants; Hydraulic Presses and Heavy Hydraulic Machinery; Pumping Engines, Centrifugal Pumping Plants; Water Works Appliances; Steel Tanks; Sugar House Apparatus; Heavy Special Machinery; Theisen Washers.

MANUFACTURERS OF C. I. Pipe, Gas Works Apparatus, Centrifugal Pumps, Hydraulic Tools of all description, Hydrants and Valves, Gas Producers.



CENTRIFUGAL PUMPING MACHINERY



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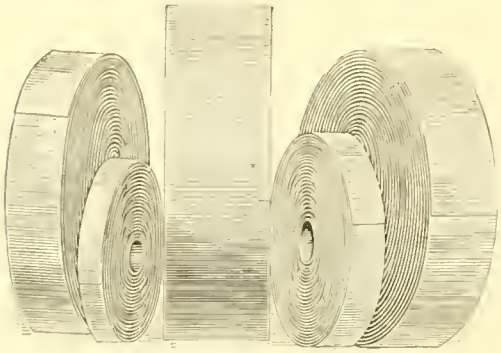
Cocheco Belting



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In the ordinary method of doing business, when you buy belting or other products, you may or may not find it profitable. However, when you buy COCHECO belting you are sure of the results expected, because

The Selling Policy Protects You

Our products are guaranteed when sold, and if the belt we send you is not as good as any other—better than most—you can send it back at our expense. You see you cannot lose.

If you want to reduce to a minimum your belting expenses, effect the greatest possible conservation of power in transmission, send for literature describing our belting.

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Mechanical, Economical, Efficient

Friction Clutch Pulleys
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Head Shaft Hangers
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HOISTS

Capacities from 1-2 to 6 Tons

Direct and Alternating Current

SIMPLE—RELIABLE
EFFICIENT
FOOL-PROOF

Sprague Hoists are cutting the cost of production in many industries.

Write for Pamphlet No. 23360

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OF GENERAL ELECTRIC COMPANY

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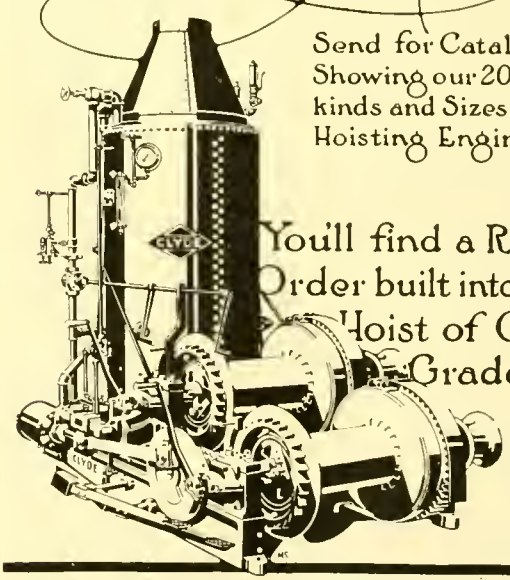
We build our best advertising into our machinery



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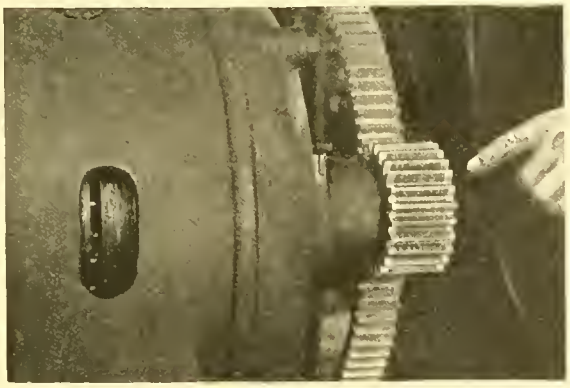
You'll find a Repeat-Order built into every Hoist of Clyde-Grade

CLYDE IRON WORKS

MANUFACTURERS of CLYDE-GRADE HOISTING MACHINERY

Duluth, Minnesota, U.S.A.



Said a Critical Buyer:

"I don't know much about electric motors but I do know something about gearing. I see you equip with NEW PROCESS NOISELESS PINIONS. I have invariably found these the best and consider their use here a good recommendation for the rest of your machine. I'll buy."

Tell us about your own product and we will tell you what benefits would be assured to your customers by the substitution of New Process for metal Pinions. Write for book "Noiseless Gear Driving."

NEW PROCESS IS TO ALL OTHER RAWHIDE AS STEEL IS TO IRON

NEW PROCESS GEAR CORPORATION
SYRACUSE, N.Y

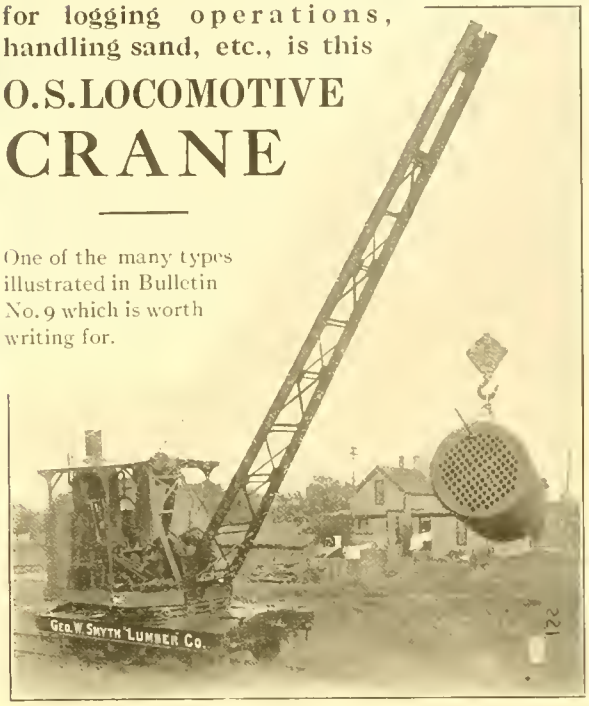
CANADIAN AGENTS: Robert Gardner & Son. Ltd., Montreal 70

A Splendid Machine

for logging operations, handling sand, etc., is this

O.S. LOCOMOTIVE CRANE

One of the many types illustrated in Bulletin No. 9 which is worth writing for.



10 Ton—8 Wheel Locomotive Crane

Orton & Steinbrenner Co.
Main Office: CHICAGO, ILL.

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Machine Tools, Electric Cranes and Engineering Specialties

SHAW ELECTRIC CRANE CO.
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THE ALLIANCE MACHINE COMPANY

ALLIANCE, OHIO

Builders of the Big Things in Cranes

We have built
The largest single trolley crane, 200-tons capacity,
The largest ladle crane, 175-tons capacity,
The largest stripper crane, 320-tons capacity,
The largest high type soaking pit crane, 25-tons capacity,
The largest slab charging crane.

The above cut shows one of the two 7½-ton Ore Bridges which we have recently built for the Pittsburg Steel Company at Monessen, Pa. The design of these bridges represents all that is good in ore bridge construction.

If you are considering the installation of an ore bridge, it will certainly pay you to get in communication with us.

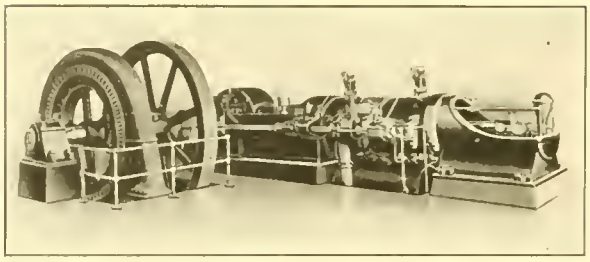
PITTSBURG — *The Largest Manufacturers of the World's Largest Cranes* — NEW YORK

THE ALLIANCE MACHINE CO.
ALLIANCE, OHIO.
ENGINEERS AND BUILDERS

BIRMINGHAM — CHICAGO

Oil-Burning BECO

STANDARD SIZES 300 to 600 B. H. P.



Is a prime mover that is

A Model of Simplicity

Free from all valves with exception of a small fuel needle valve, which uncovers an opening into the cylinder of less than ⅛ of an inch in diameter. Operates on the Diesel principle.

Guaranteed fuel consumption not in excess of 7½ gallons of crude or refuse oil per 100 B. H. P. hours.

Let us send you descriptive matter covering details of construction and operation.

HERBERT B. RUST, Sales Agent
14-22 Peck St., Providence, R. I.
THE BROWN ENGINE CO., Fitchburg, Mass.

On the Road to Efficiency

One of the milestones on the road to efficiency is the use of

TEXACO LUBRICANTS

The engineer specifying Texaco Lubricants makes long strides towards this goal. He then has lubricants working for him that are fitted to meet his strongest demands.

There are more reasons to make the use a necessity for efficient operation than we can put on this page.

Some of them are—their lubricating and staying qualities, the ease with which they separate from water, their exact suitability to particular requirements, the manner in which they eliminate "trouble"—and, to come to an end here,—the high degree of satisfaction that they are giving to Texaco consumers—and some of these are among the largest plants in the country.

Let their experience at least put you on the road to a trial of "the oils that cost less because they save more."

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Ventilated and Watertight

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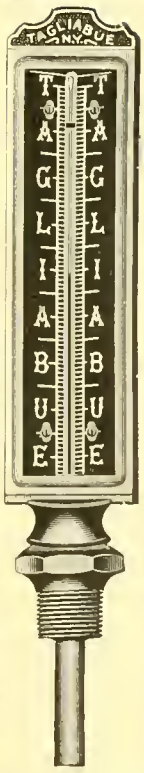
Brown Pyrometers

Are used for measuring temperatures from —200° to +3600° Fahrenheit. Over 4000 Brown Electric Pyrometers are in general service, under the most severe conditions. Our 56-page Catalogue would interest you

THE BROWN INSTRUMENT CO.

PHILADELPHIA, PA.

NEW YORK PITTSBURGH CHICAGO



"I don't spend my Company's money for repairing poor thermometers"

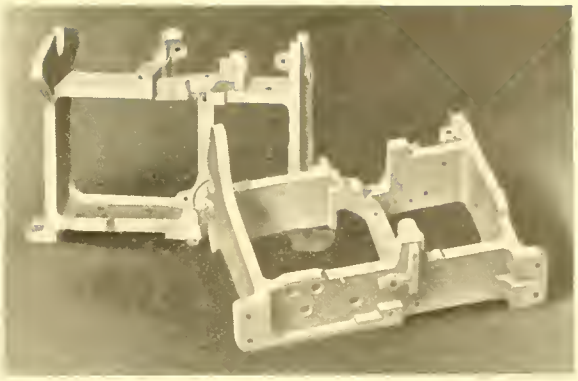
This is said by a customer of ours who buys Tagliabue-constructed Hohmann-type Thermometers because he finds that they are built for permanent use. As a matter of fact, our Thermometers are built as strong as experience and experiment show they can be.

In our Thermometer Codex the construction and use of our Tagliabue-constructed Hohmann-types are shown graphically. Sent on request.

C. J. TAGLIABUE MFG. CO.

TEMPERATURE ENGINEERS

18-88 Thirty-third St. Brooklyn, N. Y.



Increased Accuracy at Reduced Cost

The elimination of the personal element through the use of steel dies removes the liability of variation common to machined parts.

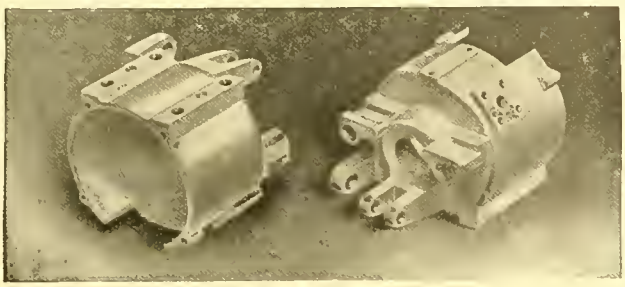
The increased rate of output makes possible prices which cannot be approached by even the best equipped machine shops.

Our twenty years' experience has made Franklin die-castings the standard for quality.

Write for Booklet "D"

Franklin Manufacturing Company

404 South Geddes Street Syracuse N Y



Here is a Splendid Opportunity to Reduce Your Production Costs

Doehler Die Castings in aluminum and white metal alloys can be made accurate to within .001 inch and with a speed and uniformity impossible with any machining method. Further, by letting us make these parts you are assured of top notch quality and prompt delivery without having to install in your plant, machines which while idle render part of your capital dormant.

Our capable engineering staff and large force of skilled die makers stand ready to help you promptly on new propositions.

DOEHLER DIE-CASTING CO.

COURT & NINTH STS.

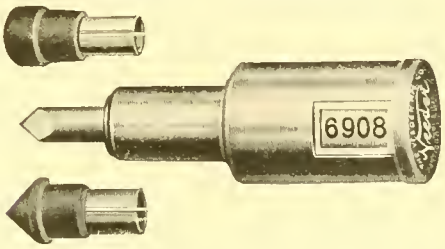
BROOKLYN, N.Y.

Western Plant: E. Woodruff & N. 12th Sts., Toledo, Ohio.

4

Veeder

Clutch Speed Counter No. 21



is without question the best instrument manufactured for finding the revolutions per minute made by a shaft, or any other revolving part.

Can be used on either high speed or low speed machinery. Speeds as high as 5000 r.p.m. can be safely measured.

A stop-watch is not needed because the register is automatically disengaged by a spring clutch and the count stops instantly when pressure is removed from the end of the instrument.

SEND FOR COMPLETE CATALOGUES DESCRIPTIVE OF VEEDER PRODUCTS.

THE VEEDER MFG. CO.

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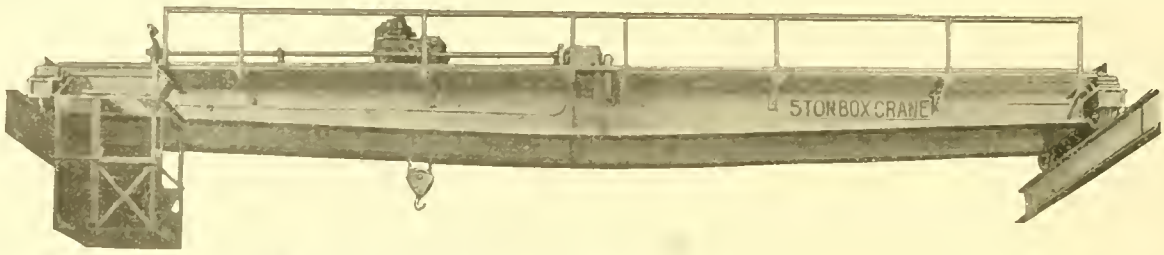
Makers of Cyclometers, Odometers, Tachometers, Tachodometers, Counters and Small Die Castings.

ELECTRIC & HAND POWER CRANES, PORTABLE ELECTRIC & MONORAIL HOISTS



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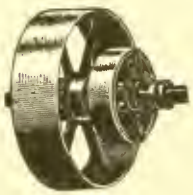
THE A. & F. BROWN CO.

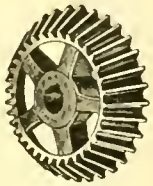
ENGINEERS, FOUNDERS, MACHINISTS AND MILLWRIGHTS



Friction Clutch Pulleys and Couplings

POWER TRANSMISSION MACHINERY

DESIGNED, FURNISHED AND ERECTED



Gears of all kinds and sizes

SPECIAL MACHINERY

IRON CASTINGS

WORKS: ELIZABETHPORT
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SALES ROOM: 79 BARCLAY ST.
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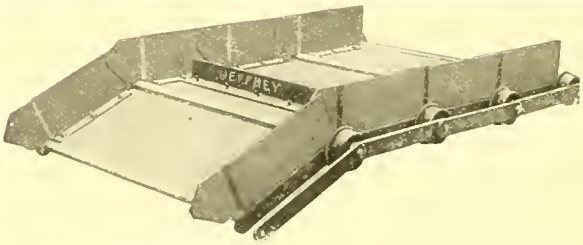

Here's a Strong, Serviceable Equipment for Handling Ores, Coal, Ashes, Coke, etc.

Jeffrey Standard Double Beaded Steel Apron Conveyer

The curved edges of the heavy steel plates stiffen the conveyer; preserve its shape; and provide a close overlapping joint between consecutive plates.

The steel apron is carried on Double Strands of Steel Thimble Roller Chains with Renewable Hardened Steel Bushings, especially adapted to this hard service.

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23 Pearl Street, Springfield, Vermont, U. S. A.

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GIVE RESULTS WHERE OTHER DRIVES FAIL

DESIGNED FOR HEAVY DUTY AND CONTINUOUS SERVICE
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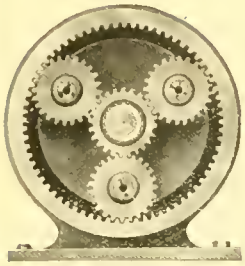

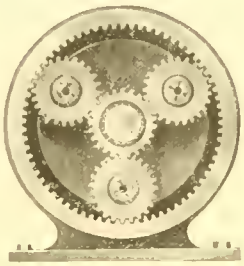

The above cut represents seven Model B Speed Reducing Outfits; ratio, 25.6 1, Direct connected to General Electric Motors, 5 H.P., 1140 R. P. M., giving a driven speed of 45 R. P. M. Motors and reducers are mounted on cast iron bedplates. The above outfits operate feed driers in a large cereal plant.

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Over 50,000 miles in use

Weber Rail Joint

Rolled from Best Quality Steel

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Makers of Base-Supported Rail Joints for Standard and Special Rail Sections, also Girder, Step or Compromise, Frog and Switch, and Insulated Rail Joints, protected by Patents.

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Put it up to Valve Specialists.

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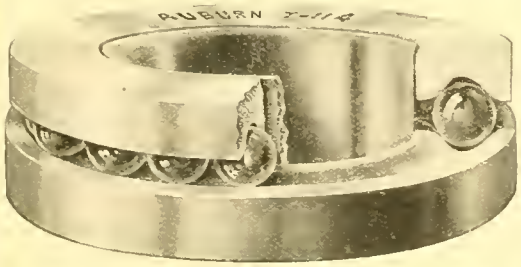
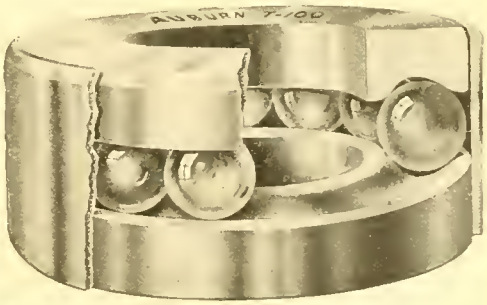
VALVE SPECIALISTS SINCE 1890

THE ANSWER TO END THRUST FRICTION TROUBLES





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Auburn Ball Thrust Bearings
"With a four-point cone contact"

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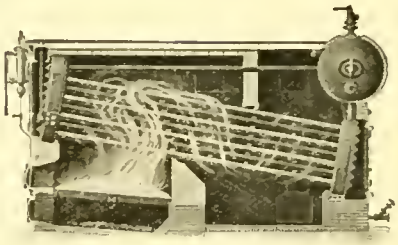
THE Cross Drum Boiler was designed to meet the demand for a high-grade water tube boiler that could be installed in office buildings, school houses, apartment houses, hotels and boiler rooms generally where ceiling height is limited or where the boiler must be introduced through restricted openings.

The boiler is shipped knocked down, and can be assembled without riveting, is of all wrought steel construction, and is built in units of from sixty to six hundred horse power.

In use by U. S. Government.



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For Water Tube and Tubular Boilers

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Catalogue "G"—Green Chain Grate Stokers for free burning bituminous coals.
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PORTLAND, ORE., Wells-Fargo Bldg.
SEATTLE, Mutual Life Bldg.
SAN FRANCISCO, 99 First Street
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ATLANTA, Candler Bldg.
HAVANA, CUBA, 116½ Calle de la Habana
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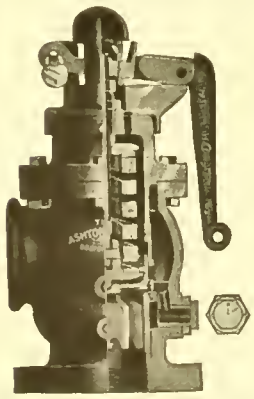

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OF BOTH REGISTERING AND RECORDING STYLES

All of a superior quality and guaranteed to give greatest efficiency, durability and perfect satisfaction. Backed by a reputation secured in 42 years of successful business.

Complete Catalogue mailed upon request.

THE ASHTON VALVE CO.

Established 1871

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128 Liberty St., NEW YORK — 174 N. Market St., CHICAGO

STEAM ENGINES, TURBINES AND BOILERS

ALMY WATER TUBE BOILER CO.

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Manufacturers of Almy Patent Sectional Water Tube Boilers for steamships, river steamers, both propeller and stern wheel, torpedo boats, fire boats, launches. Donkey Boilers for steamships and for all kinds of stationary work.

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Water Tube Steam Boilers, Steam Superheaters, Mechanical Stokers.

Water Tube Boilers

BALL ENGINE COMPANY

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Builders of Ball Single Valve Automatic and High Speed Corliss Engines with non-detaching valve gear, for direct connection, or belting to electric generators.

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DE LAVAL STEAM TURBINE CO.

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Steam Turbines, single and multi-stage, for all services. Centrifugal Pumps, single and multi-stage, for all capacities and all heads. Centrifugal Blowers and Air Compressors, and special Centrifugal Apparatus. De Laval Speed-reduction Gears.

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EDGE MOOR, DELAWARE

Builders of the Edge Moor Water Tube Boiler. Especially suitable for large power plants. Steel construction, straight tubes, all hand holes elliptical, unrestricted circulation which permits forcing fires with safety and economy.

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ERIE CITY IRON WORKS

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Boilers: water tube, horizontal tubular, return tubular, water bottom portable, open bottom portable, vertical tubular and vertical water tube. Engines: Erie City "Lentz," four valve, enclosed high speed, automatic, center crank, side crank, portable and Feed-Water Heaters from 25 to 600 h.p.

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HARRISBURG FOUNDRY & MACHINE WORKS

HARRISBURG, PA.

Manufacturers of Fleming-Harrisburg Horizontal Engines, Corliss and Single Valve, Simple, Tandem and Cross Compound.

Steam Engines

HEINE SAFETY BOILER CO.

ST. LOUIS, MO.

Heine Safety Water Tube Boilers, Heine Patent Steam Superheaters, Steel Stacks, Honsings, Flues, etc.

See pages 24, 25 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Steam Boilers

Superheaters

THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO

Manufacturers of Hamilton Corliss Engines, Hamilton High Speed Corliss Engines, High Duty Pumping Engines, Power Pumps and Compressors, Special Heavy Castings.

See pages 6, 7, 309 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Engines

Pumps

Compressors

Castings

Boilers

E. KEELER COMPANY WILLIAMSPORT, PA.

Water Tube, Internal Furnace and Return Tubular Boilers. Self-Supporting Stacks, Feed Water Heaters.

See page 27 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Engines
Centrifugal Pumps
Special Machinery

PROVIDENCE ENGINEERING WORKS PROVIDENCE, R. I.

Rice and Sargent Corliss Engines, Providence Centrifugal Pumps, Improved Greene Engines and repair parts, Special Machinery.

See page 11 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Engines
Refrigerating Machinery

THE VILTER MFG. CO. Established 1867 1070-1088 Clinton St., MILWAUKEE, WIS.

Builders of Corliss Engines, Girder or Heavy Duty Type Bed for Belted or Direct-Connected Service, medium or high speed. Ice and Refrigeration Machines.

Blast Furnace Blowing Engines

WEIMER MACHINE WORKS COMPANY LEBANON, PA.

Builders of Blast Furnace Blowing engines and equipments. Cinder and hot metal cars. Furnace Bells and Hoppers. Rolling Mill castings. Special attention paid to quick repair work and work governed by Engineers' specifications.

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Compressors
Hoists

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Engineers, Designers and Builders of High Efficiency Corliss Engines, Uniflow Engines, Poppet Valve Engines, Air Compressors, Blowing Engines, Steam and Electric Hoisting Engines, Pumping Engines and Steam Stamps.

See pages 8, 9 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

OIL AND GAS ENGINES AND GAS PRODUCERS

Oil Engines

THE BROWN ENGINE CO. FITCHBURG, MASS

Herbert B. Rust, Agent
14-22 Peck St., Providence, R. I.

Manufacturers of the BECO Oil-Burning Engine. Operates on the Diesel principle. Standard sizes 300 to 600 B.H P.

Refrigerating and Ice Making Machinery
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Refrigerating and Ice Making Machinery, 5 to 600 tons capacity; Oil Engines up to 360 B. H. P.; Gas Engines 75 to 2400 B. H. P.

See page 20 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Steam Engines
Oil Engines

FULTON IRON WORKS ST. LOUIS, MO.

Manufacturers of Corliss and Medium Speed Engines, Fulton-Tosi Oil Engines Diesel System, Cane Sugar Mills and Crushers.

Oil Engines

AUGUST MIETZ IRON FOUNDRY & MACHINE WORKS 123 Mott St. NEW YORK

Oil Engines, Marine and Stationary, 2–400 h.p., 200,000 h.p. in operation. Direct coupled or belted to Generators, Air Compressors, Pumps, Hoists, etc., etc.

NATIONAL METER COMPANY NEW YORK CHICAGO BOSTON

Nash Gas Engines and Producers are capable of running at their rated load for ten consecutive hours on one charge of fuel; will develop a B. H. P. hour on one pound of coal; are reliable because they're Nash.

See pages 18, 19 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Gas Engines and Producers

THE SMITH GAS POWER CO. LEXINGTON, OHIO

Builders of Smith Automatic Gas Producers, both suction and pressure types. Mechanically Operated Gas Producers in large units for power and heating plants. Tar Extractors and Gas Cleaning Plants.

See page 22 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Gas Producers

POWER PLANT AUXILIARIES AND SPECIALTIES

AMERICAN BALANCE VALVE CO. JERSEY SHORE, PENNA.

We make Balanced Slide and Piston Valves for Manufacturers of Steam Engines, also for Old Power Equipment, from Steam Pumps to Battleships. Write us.

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Valves

Slide and Piston Distribution

AMERICAN STEAM GAUGE AND VALVE MFG. CO. BOSTON, MASS. ESTABLISHED 1851

Pressure and Recording Gauges, Engine Room Clocks and Counters for all purposes. Iron and Brass Pop Safety and Relief Valves for stationary, marine and locomotive use. The American Thompson Improved Indicator with new improved detent motion. The American Ideal Steam Trap.

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Gauges

Indicators

THE ASHTON VALVE CO. BOSTON NEW YORK CHICAGO

Makers of the Ashton Pop Safety Valves. Water Relief Valves, Blow Off Valves, Pressure and Vacuum Gages. All of a superior quality and guaranteed to give greatest efficiency, durability and perfect satisfaction.

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Bristol's Recording Pressure and Vacuum Gauges. Bristol's Recording Thermometers. The Wm. H. Bristol Electric Pyrometers. Bristol's Recording Voltmeters, Ammeters and Wattmeters. Bristol's Recording Water Level Gauges. Bristol's Time Recorders and Bristol's Patent Steel Belt Lacing.

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Manufacturers of the Brown Pyrometers, the first to be manufactured in this country, and having the largest sale today. Also manufacturers of Thermometers, Speed Indicators and Recorders, Voltmeters, Ammeters and kindred instruments.

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Brass and Iron Valves for steam, water, gas, oil, etc. Sluice Gates. Send for catalogue.

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Grease Cups

CRESCENT MANUFACTURING CO.

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Lackawanna Sight Feed Lubricators and Automatic Grease Cups

Valve Specialties
Steam Traps
Governors

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CHICAGO
NEW YORK ST. LOUIS

Manufacturers of Pressure Reducing Valves, Back Pressure Valve, Steam Trap, Exhaust Relief Valves, Balanced Valve, Float Valve, Pump Governor, Boiler Stop and Check Valves.

See pages 104, 105 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Condensing Plants
Air Filters
Separators
Steam Traps

GENERAL CONDENSER CO.

1250 N. 12TH ST. PHILADELPHIA, PA.

Complete Condensing Plants for High Vacuum; Counter Current, Jet and Surface Condensers, Air Pumps, Pumping Outfits, Re-Cooling Plants. Oil, Air and Steam Separators. Combined Oil Separators and Heaters. Dry and Wet Air Filters. Air Extractors for Feed Water ("Airex"). Return and Vacuum Steam Traps.

Stokers
Pneumatic Ash Conveyors

GREEN ENGINEERING CO.

STEGER BUILDING CHICAGO, ILL.

Green Chain Grate Stokers for free burning and coking bituminous coals. GECO Pneumatic Ash Handling Systems.

See pages 32, 33, 34 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Fuel Economizers
Mechanical Draft
Engines

THE GREEN FUEL ECONOMIZER CO.

MATTEAWAN, N. Y.

Fuel Economizers; Waste Air Heaters; Fans, Blowers and Exhausters; Engines; Positivflow Hot Blast Heaters, Drying Equipments; Heating and Ventilating Equipments, Mechanical Draft Installations.

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Feed-Water Heaters and Purifiers
Separators
Metering Heaters

HARRISON SAFETY BOILER WORKS

PHILADELPHIA, PA.

Cochrane Feed Water Heaters, Cochrane Steam and Oil Separators, Sorge-Cochrane Hot Process Softening Systems, Cochrane Multiport Valves, Cochrane Metering Heaters.

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WORKS: HOMESTEAD, PA.
PITTSBURG, PA.

Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most diffieult service for water, air or steam. Valves unlike all others.

See page 82 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves
Steam Traps
Separators
Regulators

THE HUGHSON STEAM SPECIALTY CO.

CHICAGO, ILL.

Manufacturers of Regulating Valves for all pressures and for steam, air and water. The best and only absolutely noiseless Combination Back Pressure and Relief Valve. Pump Regulators, Separators, Steam Traps, Automatic Stop and Check Valves. Write for complete catalogue.

Air Compressors
Air Tools and Hoists

INGERSOLL-RAND COMPANY

11 BROADWAY NEW YORK

Air Compressors, twenty standard types, capacity 8 to 9000 cu. ft. per minute; "Little David," "Crown" and "Imperial" Air Hammers and Drills, all sizes "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

See pages 276, 277 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves
Packing Discs

JENKINS BROS.

NEW YORK BOSTON
PHILADELPHIA CHICAGO

Manufacturers of the genuine Jenkins Bros. Valves, made in brass, iron body, and cast steel, in a variety of types, suitable for moderate, medium or extra heavy pressures. Also a line of high grade mechanical rubber goods including sheet packing, gasket tubing and pump valves. Illustrated catalogue sent on request.

See pages 84, 85 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

ROBERT A. KEASBEY CO.

100 N. Moore St. NEW YORK CITY
Telephone: 6097 Franklin

Heat and Cold Insulating Materials. Headquarters for 85% Magnesia Asbestos and Brine Pipe Coverings, Asbestos Products, etc.

See page 138 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Magnesia Asbestos and Brine Pipe Coverings

THE LAGONDA MFG. CO.

SPRINGFIELD, OHIO

Makers of Weinland Tube Cleaners, Automatic Cut-Off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers.

Tube Cleaners

Cut-Off Valves

Water Strainers

THE LUDLOW VALVE MFG. CO.

TROY, N. Y.

Manufacturers of genuine Ludlow Gate Valves for all purposes. Special Blow-off Valves. Check Valves. Foot Valves. Sluice Gates. Indicator Posts. Fire Hydrants.

See pages 86, 87 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves

Blow-off Valves

Fire Hydrants

THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

Manufacturers of high-grade engineering specialties, comprising Brass and Iron Valves, Whistles, Cocks, Gauges, Injectors, Lubricators, Oil Pumps, Oil and Grease Cups, etc., adapted to the requirements of all classes of machinery.

See pages 88–93 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves

Injectors

Lubricators Etc.

MOREHEAD MANUFACTURING CO.

DETROIT, MICH.

Return, Non-Return, Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

See pages 112, 113 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Steam Traps

THE MURPHY IRON WORKS

Founded 1878 Inc. 1904 DETROIT, MICH.

Builders of The Murphy Automatic Furnace. The best Automatic Furnace that thirty years practical experience can produce.

See pages 38, 39 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Automatic Furnace

NELSON VALVE CO.

Chestnut Hill PHILADELPHIA, PA.

Manufacturers of high grade Bronze, Iron and Steel Valves of every kind for every purpose.

See page 94 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves

THE PICKERING GOVERNOR CO.

PORTLAND, CONN.

Governors for Steam Engines, Turbines, Gas Engines. Mechanical Control Power Regulation.

See page 131 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Governors

POWER SPECIALTY CO.

111 Broadway NEW YORK

The Foster Patent Superheater saves feed water, condensing water, coal and boiler power.

See page 45 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Superheaters

NATIONAL PIPE BENDING CO.

NEW HAVEN, CONN.

National Feed-Water Heaters, National Storage Heaters, National Direct Contact Heaters and Purifiers, National Steam and Oil Separators. Coils and Bends of Iron, Brass and Copper Pipe.

See pages 62, 63 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Feed-Water Heaters and Purifiers

Separators

Valves

Fire Hydrants

PRATT & CADY COMPANY, Inc.

HARTFORD, CONN.

BRANCHES AT ALBANY, BALTIMORE, BOSTON, CHICAGO, DETROIT, INDIANAPOLIS, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURG.

Manufacturers of Brass, Iron and Steel Valves, Fire Hydrants, Asbestos Packed Cocks.

See pages 96, 97 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Water Softening

Purifying and Filtering Systems

WM. B. SCAIFE & SONS COMPANY

221 FIRST AVE. PITTSBURGH, PA.
26 CORTLANDT ST. NEW YORK

WE-FU-GO and SCAIFE Water Softening, Purifying and Filtering Systems for boiler feed water and all industrial and domestic purposes.

Injectors

Condensers

Valves

Engine Stops

SCHUTTE & KOERTING CO.

1239-57 N. 12TH ST. PHILADELPHIA, PA.

Injectors, Syphons, Eductors, Furnace Blowers, Exhausters, Pump Primers, Condensers, Spray Cooling Nozzles; Valves; Small Brass and Iron Body, Open Hearth Steel-Stop, Stop Check, Emergency Stop Check, Trip, Throttle Trip, Engine Stops, Steam Traps, Feed Water Heaters, etc.

Steam Specialties

Feed Water Heaters

Steam Separators

THE SIMS COMPANY

ERIE, PENNA.

Designers and Manufacturers of Steam Specialties and Power Plant Appliances: Closed Feed Water Heaters, Open Feed Water Heaters, Hot Water Generators-Convertors, Laundry Heaters, Live Steam and Water Mixers, Exhaust Heads, Oil Extractors, Oil Filters, Compound Feeders, Garbage and Refuse Burners, Tanks.

Instruments

C. J. TAGLIABUE MFG. CO.

32 THIRTY-THIRD ST. BROOKLYN, N. Y.
Local Sales Offices in Chicago and San Francisco

Manufacturers of Instruments for Indicating, Recording and Controlling Temperature and Pressure. Thermometers; Automatic Controllers; Gages; Oil Testing Instruments; Engineers' Testing Sets, Pyrometers, Barometers, Hygrometers, Hydrometers, etc.

See Page 132 *of Condensed Catalogues of Mechanical Equipment.*

Lubricating Oils

THE TEXAS COMPANY

NEW YORK HOUSTON

Lubricating Oils for Power Plants, Central Stations, Machine Shops, Foundries and all general purposes. All classes of Petroleum Products of the highest quality.

See page 142 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Condensers

Pumps

Cooling Towers

WHEELER CONDENSER & ENGINEERING CO.

MAIN OFFICE AND WORKS: CARTERET, N. J.

Surface, Jet and Barometric Condensers, Combined Surface Condensers and Feed Water Heaters, Cooling Towers, Edwards Air Pumps, Centrifugal Pumps, Rotative Dry Vacuum Pumps and Multiple Effect and Evaporating Machinery.

See page 66, 67 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Condensers

Cooling Towers

Feed-Water Heaters

C. H. WHEELER MFG. CO.

PHILADELPHIA, PA
NEW YORK BOSTON
CHICAGO SAN FRANCISCO

Manufacturers of High Vacuum Apparatus, Condensers, Air Pumps, Feed-Water Heaters, Water Cooling Towers, Boiler Feed and Pressure Pumps.

See page 65 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Water Meters

Blow-off Valves

Pipe-Joint Clamps

YARNALL-WARING CO.

CHESTNUT HILL PHILADELPHIA, PA.

Manufacturers of the "Lea" V-Notch Recording Meter, Simplex Seatless Blow-off Valve and the Simplex Pipe-Joint Clamp.

See page 95 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves

Power Plant Piping

Wrenches

WALWORTH MANUFACTURING CO.

BOSTON, MASS.

Manufacturers of high grade Brass, Iron and Steel Valves; Power Plant Piping; Screwed and Flanged Fittings; Pipe Fitter's Tools; Genuine Stillson Wrenches, Parmelee Wrenches, Walco-Hex Wrenches.

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THE AMERICAN PULLEY CO.
PHILADELPHIA, PA.

Pulleys

The American Pulley. The first all steel parting belt pulley made. Now sold in larger quantities than any one make of pulley. No key, no set screw, no slip; light, true and amply strong for double belts. 180 stocks carried in the United States.

See pages 158, 159 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

AUBURN BALL BEARING COMPANY
22 Elizabeth St. ROCHESTER, N. Y.

Ball Bearings

Auburn Four Point Contact Cone Principle Ball Thrust Bearings, Auburn Special Ball Thrust Bearings, Auburn Steel, Brass and Bronze Balls, Solid and Hollow.

See page 161 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

THE A. & F. BROWN CO.
79 Barclay St. NEW YORK

Shafting
Pulleys
Hangers

Manufacturers of Shafting, Pulleys, Hangers, etc., for Transmission of Power.

See page 148 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

DODGE MANUFACTURING CO.
MISHAWAKA, IND.

Power Transmission
Elevators
Conveyors

Manufacturers of everything for the Mechanical Transmission of Power; also Elevating and Conveying machinery, and the "Eureka" Water Softener. Our new catalog 106A14 gives an idea of the Dodge line.

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Sales Agents: The Rhineland Machine Works Co., 140 W. 42nd St. New York City

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High grade Ball Bearings made of the finest materials to the closest standards of accuracy in the world. Fafnir Ball Bearing Hanger Boxes can be used in any standard hanger frame.

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Power Transmission Appliances

Friction Clutch Pulleys, Couplings, Quills, Operators, Clutch Sheaves, Floor Stands, Heavy Mill Bearings, Shaft Couplings, Sheaves and Tension Carriages, Pulleys and Fly Wheels.

See page 149 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

THE HILL CLUTCH COMPANY
CLEVELAND, OHIO

Power Transmission

Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

See page 156 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

D. O. JAMES MANUFACTURING CO.
1120-22 W. Monroe St. CHICAGO

Cut Gearing
Speed Reducing Transmissions

Specialists in cut gearing; spur, spiral, bevel, mitre, worms and worm gears, rawhide pinions, racks, incased worm gear reductions, O'K speed reducing transmissions 4:1 up to 1600:1.

NEW PROCESS GEAR CORPORATION
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Manufacturers of New Process Noiseless Pinions and also of accurately cut Metal Gears of all kinds.

Pulleys

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Rockwood Paper Frictions have proven their unquestioned superiority. You will find our booklets regarding Transmission of Power by Belts and Friction Transmission desirable additions to your engineering library. Furnished free to members upon application.

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Tanners and Manufacturers of Oak Tanned Leather Belting, Round Belting, Lace Leather, Belt Leather, Welting, Strapping, Finished Oak Shoulders, Slabs, Bellies, Scrap Leather.

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Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

See pages 154, 155 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

Power Transmission

Roller Bearings

ROYERSFORD FOUNDRY AND MACHINE CO. PHILADELPHIA, PA.

Manufacturers of Power Transmission Machinery and Sells Roller Bearings.

See pages 168, 169 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

HOISTING AND CONVEYING MACHINERY

Cranes

Steam Hammers

Punches and Shears

ALLIANCE MACHINE CO. ALLIANCE, OHIO

Makers of Alliance Cranes of all types; also Rolling Mill and Hydraulic Machinery, Steam Hammers, Punches and Shears, Scale Cars, Copper-Converting Machinery, etc.

See page 199 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

Cranes and Hoists

ALFRED BOX AND COMPANY PHILADELPHIA, PA.

Electric and Hand Power Cranes, Portable Electric and Monorail Hoists, Complete Track Systems.

Hoisting Machinery

THE BROWN HOISTING MACHINERY CO. CLEVELAND, O., U. S. A. New York San Francisco Pittsburgh Chicago

Designers and Manufacturers of all kinds of Hoisting Machinery, including Locomotive Cranes, Electric Travelers, I-beam Trolleys, Crabs, Winches, etc., as well as heavy Hoisting Machinery of all descriptions. Also Ferroinclave for reinforced concrete roofing.

See page 201 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

Conveyors

Elevators

Power Transmission

H. W. CALDWELL & SON COMPANY NEW YORK CHICAGO

Elevating, Conveying and Power Transmitting Machinery. Helicoid and screw conveyors, machine molded gears, pulleys, fly-wheels, rope sheaves and drives, sprocket wheels and chain, buckets, belting, shafting and bearings.

See page 187 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

Hoisting Engines and Derricks

CLYDE IRON WORKS DULUTH, MINN.

Hoisting Engines and Derricks. All sizes and types of engines.

See page 204 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

THE EASTERN MACHINERY COMPANY
NEW HAVEN, CONN

Manufacturers of Electric and Belt Power Passenger and Freight Elevators, Hoisting Machines, Friction Winding Drums, Friction Clutches and Friction Clutch Pulleys.

Elevators
Friction Clutches
Pulleys

THE B. F. GOODRICH CO.
AKRON, OHIO

Manufacturers of Goodrich Conveyor Belt. The Goodrich "Longlife" "Maxecon" and "Grainbelt" Conveyors will handle more tons per dollar of cost than any other belt made.

See pages 146, 175 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

Conveyor Belts

THE JEFFREY MFG. COMPANY
COLUMBUS, OHIO

Builders of Elevating, Conveying and Mining Machinery; Coal and Ashes Handling Systems for Power Plants; Screens, Crushers, Pulverizers, Car Hauls, Coal Tipples, Coal Washeries, Locomotives, Coal Cutters, Drills, etc. Complete Coal Mine Equipments.

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Conveying
Mining Machinery

LIDGERWOOD MFG. CO.
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Hoisting Engines—steam and electric, for every use of the contractor, miner, warehouseman, railroads, shipowners, etc. Derricks, Derrick Irons and Derrick Hoists, Cableways for hoisting and conveying, Marine Transfer for coal and cargo handling.

Hoisting Engines
Cableways
Marine Transfers

LINK-BELT COMPANY
PHILADELPHIA CHICAGO INDIANAPOLIS

Elevators and Conveyors for every purpose; all accessories; Power Transmission Machinery. The Link-Belt Silent Chain Drive, Coal Tipples, Coal Washeries, Locomotive Cranes, etc.

See page 192 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

Elevators and Conveyors

MATHEWS GRAVITY CARRIER CO.
ELLWOOD CITY, PA.

Manufacturers of Gravity Carriers, Conveyers, Spirals, Chutes, and Automatic Elevators. Engineering Department at your service.

Gravity Carriers
Conveyers
Automatic Elevators

THE MORGAN ENGINEERING CO.
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Are the largest builders of Electric Traveling Cranes in the world. We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

Cranes

ORTON & STEINBRENNER CO.
CHICAGO, ILL.

Manufacturers of Material Handling Machinery: Locomotive and Special Cranes, Elevating and Conveying Machinery, Coal Crushers, Coal and Ore Handling Plants, Automatic Buckets, Drag Line Excavators.

Locomotive Cranes
Grab Buckets
Coal Crushers

ROBINS CONVEYING BELT COMPANY
13 PARK ROW NEW YORK

The Robins Belt Conveyor was the original and is today the standard of this type of conveying machinery. It is successfully and economically conveying ore, rock, coal and similar materials under the most trying conditions of service. Correspondence invited.

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Robins Belt Conveyors

JOHN A. ROEBLING'S SONS COMPANY
TRENTON, N. J.

Manufacturers of Iron, Steel and Copper Wire Rope, and Wire of every description.

See page 185 *of Condensed Catalogues of Mechanical Equipment,* 1913 *Volume.*

Wire Rope

Cranes
Mono-Rail Systems
Controllers

SHAW ELECTRIC CRANE CO. MUSKEGON, MICH.

Electric Travelers for all purposes. Gantries. Wharf Cranes. Railroad Wrecking Cranes. Mono-Rail Systems. Electric Motor Controllers.

Cranes
Hoists

THE TOLEDO BRIDGE & CRANE CO. TOLEDO, OHIO

Toledo Cranes and Hoists; Coal and Ore Handling Bridges; Grab Bucket Machinery; Electric and Hand Power Cranes, all types, any capacity; Structural Steel for Factory Buildings.

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Conveying
Power Transmitting Machinery

THE WEBSTER M'F'G COMPANY (Successors to WEBSTER M'F'G CO.) TIFFIN, OHIO
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Manufacturers of Elevating, Conveying and Power Transmitting Machinery for all purposes. Over thirty years' experience in this line and extensive facilities for manufacturing give us large advantages. Belt Conveyors for handling cements, ores, sand, gravel, etc. Coal and Ash Handling Systems for power plants and buildings. Chain belting. Gearing.

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Makers of the Triplex Block and Electric Hoists. The Triplex Block is made in 14 sizes, with a lifting capacity of from ¼ to 20 tons; Electric Hoist in 10 sizes, ¼ to 16 tons.

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Engines
Rolling Mill Machinery

MACKINTOSH, HEMPHILL & CO. PITTSBURGH, PA

Engines, single and compound, Corliss reversing and blowing. Rolling Mill and Hydraulic Machinery of all kinds. Shears, Punches, Saws, Coping Machines.

Steel Works and Rolling Mill Equipment

MESTA MACHINE CO. PITTSBURGH, PA.
WORKS: Mesta Station, P. R. R., W. Homestead, Pa.

Blowing Engines; Rolling Mills; Pickling Machines; Shears; Forging Presses; Gas and Steam Engines; Condensers; Air Compressors; Power Transmission Machinery; Steel Castings; Chilled, Sand and Steel Rolls.

Papers on Rolling Mill Machinery

PAPERS PUBLISHED BY A. S. M. E.

No. 868. Some Landmarks in the History of the Rolling Mill: C. H. Morgan, price $0.20; No. 1319. Pressure Recording Indicator for Punching Machinery: C. C. Anthony, price $0.10; No. 1322. Power Forging, with special Reference to Steam Hydraulic Forging Presses: B. Gerdau and G. Mesta, price $0.10.

FOUNDRY EQUIPMENT

Sand Rammers
Air Tools and Hoists
Compressors

INGERSOLL-RAND COMPANY 11 BROADWAY NEW YORK

"Crown" Sand Rammers, floor and bench types; "Little David," "Crown" and "Imperial" Chipping Hammers; "Imperial" Air Motor Hoists, ½ to 5 tons capacity; Air Compressors, twenty types, capacity 8 to 9000 cu. ft. per minute.

See pages 276, 277 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

MUMFORD MOLDING MACHINE CO. 2075 Elston Ave. CHICAGO, ILL.

Squeezing Machines, Hand or Power
Jolt Ramming Machines, Pneumatic or Electric
Split Pattern Vibrator Machines
Pneumatic Vibrators

See page 216 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Foundry Molding Machine Equipment

MACHINE SHOP EQUIPMENT

C. H. COWDREY MACHINE WORKS FITCHBURG, MASS.

Contractors, Builders and Designers of Special Machinery.

Special Machinery

THE FELLOWS GEAR SHAPER CO. SPRINGFIELD, VT.

Manufacturers of Gear Cutting Machinery of the Most Advanced Type. In the Gear Shaper System a generating cutter is used which is ground after it has been hardened.

See page 235 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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FORTUNA MACHINE CO. 127 Duane St. NEW YORK
Boston, 146 Summer St.
St. Louis, 200 N. 3rd St.

Portable Electric Tools for Drilling, Reaming, Tapping, Grinding and Slotting.

Portable Electric Tools

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Manufacturers of a complete line of Plain and Universal Milling Machines, Screw Machines, Monitor Lathes, Tapping Machines, Duplex Drill Lathes, Speed Lathes, Cutter Grinders, Automatic Chucks, etc.

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THE HARTFORD SPECIAL MACHINERY CO. HARTFORD, CONN.

Builders of High Grade, Accurate, Special Machinery, Fixtures, Jigs and Tools.

Special Machinery

THE HEALD MACHINE COMPANY WORCESTER, MASS.

Manufacturers of Grinding Machines. Internal Grinders, Cylinder Grinders, Surface Grinders, Drill Grinders.

Grinding Machines

INGERSOLL-RAND COMPANY 11 Broadway NEW YORK

Air Compressors, twenty standard types, capacity 8 to 9000 cu. ft. per minute; "Little David," "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

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Air Compressors

Air Tools and Hoists

JONES & LAMSON MACHINE CO. SPRINGFIELD, VT.

Manufacturers of the Hartness Flat Turret Lathe; made in two sizes for both bar and chuck work.

See pages 220–225 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Turret Lathes

Heavy Duty Boring Mills

THE KING MACHINE TOOL CO. CINCINNATI, O.

Vertical Turret Machines, 28″ and 34″. Vertical Boring and Turning Machines, 42″ to 84″, inclusive.

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We manufacture a complete line of Heavy Duty Lathes and Milling Machines. They are scientifically designed, so the power is limited only by the strength of the cutting tool. It will pay you to investigate our machines. Catalogue upon request.

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Branch Offices:
New York Chicago Detroit

We offer a most complete line of high-grade Turret Lathes for producing work accurately, rapidly and economically. Our catalog, which describes these machines fully, will be mailed on request.

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Taps and Dies

WELLS BROTHERS COMPANY GREENFIELD, MASS.

We make and sell the Little Giant line of Taps, Dies, Screw Cutting Tools and Machinery.

Papers on Machine Shop Practice

PAPERS PUBLISHED BY A. S. M. E.

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Generators, motors, Curtis steam turbines, switchboards, transformers, locomotives, lighting equipments, air compressors, electrically heated devices for industrial purposes. Largest manufacturer of electrical apparatus in the world.

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Generators

Motors

Hoists

Fans

SPRAGUE ELECTRIC WORKS 527-531 W. 34th St. NEW YORK
of General Electric Co.

Manufacturers of D. C. Generators, Electric Motors, Electric Hoists, Electric Fans, Conduits, Armored Cable, Outlet Boxes, Armored Hose.

Dynamos

Motors

Transformers

Instruments

WAGNER ELECTRIC MANUFACTURING COMPANY ST. LOUIS, MO.

Single-Phase Motors. Polyphase Motors. Transformers, Power and Pole Type. Instruments, a complete line. A. C. Generators. Converters for charging vehicle batteries from A. C. Rectifiers for charging small storage batteries from A. C. Train Lighting (Electric) Equipments. Automobile Self Starters (Electric), etc.

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Precision Instruments

Manufacturers of Miniature Precision Instruments for Direct Current. Over 300 ranges and types for various purposes.

PAPERS PUBLISHED BY A. S. M. E.

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No. 472. Electric Power Distribution: H. C. Spaulding, price $0.20; No. 485. The Electric Railway as applied to Steam Roads: B. J. Dashiell, Jr., price $0.10; No. 845. The Mechanical Equipment of the New South Station: W. C. Kerr, price $1.00; No. 1043. Middlesborough Dock Electric and Hydraulic Power Plant: V. L. Raven, price $0.30.

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INGERSOLL-RAND COMPANY

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Tools

Hoists and Sand Rammers

Twenty standard Air Compressor types, capacity 8 to 9000 cu. ft. per minute; "Little David," "Crown" and "Imperial" Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, ½ to 5 tons capacity; "Crown" Sand Rammers, floor and bench types.

See pages 276, 277 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

PAPERS PUBLISHED BY A. S. M. E.

Papers on Air Compressors and Pneumatic Tools

No. 1320. Commercial Application of the Turbine Turbo-Compressors: R. H Rice, price, $0.30; No. 830. Compression and Liquidification of Gas: A. L. Rice, price $0.10; No. 804. A Pneumatic Despatch-tube System for Rapid Transportation of Mails in Cities: B. C. Batcheller, price $0.30; No. 1295. The Development of the Air Brake: (Presidential Address) G. Westinghouse, price $0.20.

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Vacuum Pumps and Condensers

Vacuum Drying Apparatus (Passburg's Patents), High Efficiency Vacuum Pumps and Condensers. Drying experiments with various materials may be made at our experimental station.

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CONNERSVILLE, IND.

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Gas Exhausters

Pumps

Positive Pressure Blowers for foundries. High Pressure Blowers. Blowers for vacuum cleaning, for laundries, for blacksmiths. Positive Rotary Pumps. Positive Pressure Gas Exhausters. High Pressure Gas Pumps. Flexible Couplings.

See pages 282, 283 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

RUGGLES-COLES ENGINEERING CO.

McCormick Bldg. CHICAGO
Hudson Terminal NEW YORK

Dryers

Dryers. Direct heat, Indirect heat, and Steam Dryers for all kinds of materials.

See page 301 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

B. F. STURTEVANT COMPANY

HYDE PARK, MASS.

Fans

Blowers

Economizers

Engines

We make equipment to force or exhaust air under all conditions. Largest standard line of "ready to deliver" Fans in the world and special work done where necessary. Consulting representatives in or near your city.

See pages 48, 49 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

PUMPS AND HYDRAULIC TURBINES

Pumps
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M. T. DAVIDSON CO.

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High grade economical Pumps for all services. Surface and Jet Condensers.

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Manufacturers of Efficient Triplex Power Pumps for general water supply, municipal water-works, fire protection, hydraulic elevators, paper and pulp mills, boiler feed pumps, chemical pumps and air compressors, rotary, centrifugal and well pumps and hand pumps of every kind.

See page 291 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Water Wheels
Wood Pulp and Paper Machinery

HOLYOKE MACHINE COMPANY

HOLYOKE, MASS
WORCESTER, MASS.

Water Wheels with Connections and Complete Power Transmission, Water Wheel Governors, Gearing, Wood Pulp and Paper Machinery, Pumps, Hydraulic Presses. Special Machinery to order.

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J. & W. JOLLY, Inc.

HOLYOKE, MASS.

McCormick Holyoke Turbines designed to suit Mill or Hydro-Electric Work. Paper Mill Machinery, Shafting, Gearing, Pulleys and Freight Elevators.

See page 298 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Vacuum Pumps

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215–221 N. Wood St. CHICAGO, ILL.

Engineers and Machinists.
Manufacturers of Rotary Vacuum Pumps for highest dry vacuum, Lead Pumps, Rotary Blowers, etc.

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I. P. MORRIS COMPANY

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Specialists in the design and construction of high class, high efficiency Hydraulic Turbines.

See page 299 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Centrifugal Pumping Machinery
Engines

MORRIS MACHINE WORKS

BALDWINSVILLE, N. Y.

Manufacturers of Centrifugal Pumping Machinery, Vertical and Horizontal Engines and Marine Engines.

See pages 292, 293 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*

Gas Holders
Pumping Machinery
Hydraulic Machinery
Gas Producers

R. D. WOOD & COMPANY

PHILADELPHIA, PA.

Engineers, Iron Founders, Machinists:—Builders of Gas Holders, Gas Plants, Gas Producer Power Plants, Hydraulic Presses and Heavy Hydraulic Machinery, Pumping Engines, Centrifugal Pumping Plants, Water Works Appliances, Steel Tanks, Sugar House Apparatus, Special Machinery. Manufacturers of C. I. Pipe, Gas Works Apparatus, Centrifugal Pumps, Hydraulic Tools of all description, Hydrants and Valves, Gas Producers.

See pages 296, 297 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Papers on Pumps and Hydraulic Turbines

PAPERS PUBLISHED BY A. S. M. E.

No. 381. Standard Method of Conducting Duty Trials of Pumping Engines: Committee Report, price $0.30; No. 1144. Balancing of Pumping Engines: A. S. Nagle, price $0.10; No. 1110. Development of Water-wheel Governor: M. A. Replogle, price $0.20; No. 1113. Turbine Design as Modified for Close Regulation: G. A. Bovinger, price $0.10.

ENGINEERING MISCELLANY

ALUMINUM COMPANY OF AMERICA
PITTSBURGH, PA

Aluminum Ingot, Sheet, Rod, Wire, Cable, Tubing and other forms.

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Aluminum

DOEHLER DIE-CASTING CO.
BROOKLYN, N. Y.

Our methods and processes for producing Die-Castings are generally conceded to be the most reliable and efficient known. Send for our latest booklet "Successful Die Casting."

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FAIRMONT MINING MACHINERY CO.
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Manufacturers and Jobbers of Coal Mine Equipments and Supplies: Steel Mine Ties, Car Hauls, Car Retarders, Self-Oiling Wheels, Power Coal Augers, Box Car Loaders, Portable Mine Pumps, Mine Fans.

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Makers of Base-Supported Rail Joints for Standard and Special Rail Sections, also Girder, Step or Compromise, Frog and Switch, and Insulated Rail Joints, protected by patents.

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Rail Joints

THE H. B. SMITH CO.
WESTFIELD, MASS.

Sectional Cast Iron Water Tube and Return Flue Boilers. Also Direct and Indirect Radiators for Steam and Water Warming.

See pages 326, 327 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Heating Boilers

Radiators

UNION DRAWN STEEL CO.
BEAVER FALLS, PA.

Makers of Bright Cold Finished Bessemer, Open Hearth Crucible and Alloy Steels, in Rounds, Flats, Squares, Hexagons and Special Shapes.

See page 263 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Bright Cold Finished Steel Bars

THE VEEDER M'F'G CO.
HARTFORD, CONN.

Makers of Cyclometers, Odometers, Tachodometers, Tachometers, Counters and Fine Die Castings.

See page 329 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Odometers

Tachometers

Counters

Die Castings

ELECTRIC WATER STERILIZER CO.
SCOTTDALE, PA.

Manufacturers of Electrical and Mechanical Water Purifying Machinery. Our Electric Water Sterilizing Machine is both economical in consumption of electric current and so simple that any one of average intelligence can take care of it. Guaranteed to deliver pure water. Capacities of stock machines from 40 to 1000 gallons per hour.

Water Purifying Machinery

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Industrial Engineers and Architects
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Engineers—Constructors
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ELECTRICAL TESTING LABORATORIES, Inc.
Electrical and Mechanical Laboratories
Tests of Electrical Machinery, Apparatus and Supplies. Materials of Construction, Coal, Paper, etc. Inspection of Material and Apparatus at Manufactories.
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Consulting Engineers
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Plans, Specifications and Superintendence of Manufacturing Buildings, Plants and Equipments of same.
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POLYTECHNIC INSTITUTE OF BROOKLYN
Course in Mechanical Engineering. Evening Post-Graduate Courses. Fred. W. Atkinson, Ph. D., President; W. D. Ennis, Member A. S. M. E., Professor Mechanical Engineering.

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Courses in Civil, Mechanical, Electrical and Chemical Engineering and General Science leading to the degrees, C. E., M. E., Ch. E. and B. S. Also special courses.
Unsurpassed laboratories.
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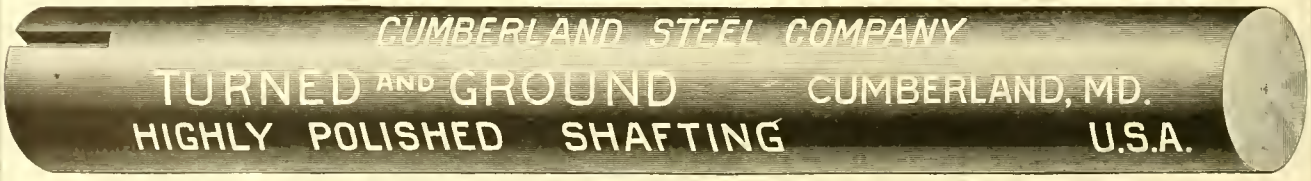

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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JUNE · 1914

SPRING MEETING, ST. PAUL-MINNEAPOLIS
JUNE 16-19

PROFESSIONAL OPPORTUNITIES

COMPETENT ENGINEERS are continually finding it advisable or necessary to seek positions offering opportunity for greater usefulness and promotion.

The Society's Bureau of Information regarding such openings is constantly assisting the members by placing them in positions where opportunity for advancement exists. Obviously, it serves equally the firms desiring competent men in any specialty.

Members are privileged to insert without charge a notice under either of the headings in the Employment Bulletin (see page LII).

There are two excellent reasons why every member should arrange to have his concern notify the Secretary whenever there is about to be an opening which a fellow member might fill.

First. The recommendation of the Society of one of its members assures the employer that he is getting an assistant of known responsibility.

Second. No fee is charged either employer or employee.

During the past year, over a hundred positions have been filled through the medium of the Bureau of Information at salaries ranging from $1,000 even up to $10,000.

This is the *Society of the Industries* and an invitation is extended to all industrial enterprises irrespective of whether or not they are at present employers of our members to avail themselves of the courtesies of the Employment Bulletin. Firms who do not employ a member of the Society may secure the service only after investigation by the Secretary.

This service is but one of the many advantages of membership in the Society.

A register of consulting engineers and industrial specialists is also maintained and is available to those interested.

Service is the motto of the Society. Try it.

Total Membership of the Society, May 15, 1914.....5516
New Members since January 1, 1914.....214

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 JUNE 1914 Number 6

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C 55. The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

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COMING MEETINGS OF THE SOCIETY

June 3, *St. Louis, Mo.*, Engineers Club. Paper: Oil Engines with Special Reference to Fulton-Tosi Oil Engines, by H. R. Setz. Illustrated by lantern slides.

Spring Meeting, June 16–19, *St. Paul-Minneapolis.* See p. III.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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Volume 36 June 1914 Number 6

THE SPRING MEETING: There is no more interesting or remarkable section of the country for a meeting of engineers than St. Paul and Minneapolis where the Spring Meeting will be held June 16-19. Several of the professional papers will deal with great engineering developments of the Northwest, with moving pictures showing ore handling on the Great Lakes. Chief among the social events will be a visit to the home of Mr. Gebhard Bohn, a beautiful estate on Lake Minnetonka. There will be an opportunity to visit the milling district of Minneapolis, with its daily output of 84,000 bbl. of flour, and the water power developments of the Mississippi. Arrangements have been completed for an excursion to Duluth with its harbor having a tonnage second only to New York in the United States, chiefly of ore, grain and coal. Members will go from Chicago to St. Paul in a splendidly equipped special train making stops en route.

PROGRAM FOR THE SPRING MEETING

Tuesday, June 16, St. Paul

2.00 p.m. Opening of headquarters and registration.
5.00 p.m. Council meeting.
8.30 p.m. Reception.
9.30 p.m. Introductory remarks by the chairman of the local committee, Max Toltz. Welcome to Minnesota by Governor A. O. Eberhardt. A response by James Hartness, President of The American Society of Mechanical Engineers, followed by a message to the engineering fraternity, especially the mechanical engineering profession, by James J. Hill, former president of the Great Northern System.
10.00 p.m. Dancing and refreshments.

Wednesday, June 17, St. Paul

10.00 a.m. Business meeting. Proposed amendments to the Constitution and announcement of ballot on amendments to C-9 and C-11. Discussion of report of Committee on Flanges. Report of Committee on Boiler Specifications.

PROFESSIONAL SESSION

Pulverized Coal Burning in the Cement Industry, R. C. Carpenter

Pulverized Coal for Steam Making, F. R. Low

Topical Discussion on Powdered Fuel

During the morning the ladies will be shown about the city and will be entertained at luncheon.

1.00 p.m. Adjournment for luncheon. (Conference luncheon for members of Council with representation of the local committees and sections)

Wednesday Afternoon

MISCELLANEOUS SESSION, 2.30 P.M.

Industrial Service Work in Engineering Schools, J. W. Roe

Classification and Heating Value of American Coal, Wm. Kent

The Railroad Track Scale, W. W. Boyd

Gear Testing Machine, Wilfred Lewis

A Flow Metering Appliance, A. M. Levin

Wednesday Evening

8.15 p.m. Lecture on Iron Ore Handling, with moving pictures, by John Hearding, superintendent, Oliver Iron Mining Company, Duluth.

Thursday, June 18, Minneapolis

9.15 a.m. Leave for Minneapolis by trolley.

PROFESSIONAL SESSION, 10.00 A.M.

Meeting in the main engineering building, University of Minnesota, Minneapolis. Opening address by a member of the engineering faculty.

Power Development at the High Dam Between Minneapolis and St. Paul, Adolph F. Meyer

The Handling of Coal at the Head of the Great Lakes, G. H. Hutchinson

Minneapolis Flour Milling, Charles A. Lang

During the morning the ladies will be shown about Minneapolis in automobiles.

Thursday Afternoon

1.00 p.m. Luncheon at the University.

2.30 p.m. Members and guests leave by train for Lake Minnetonka to visit the estate of Mr. Gebhard Bohn. Supper will be served, followed by dancing.

10.00 p.m. Party will leave by train, due in Minneapolis at 10.30 and in St. Paul at 10.45

Friday, June 19, St. Paul-Minneapolis

Technical excursions in St. Paul and Minneapolis (see loca program).

2.00 p.m. Council meeting.

2.30 p.m. Trip to Duluth. On arrival at 6.30 p.m., the party will be received by local members and given an opportunity on Saturday to see the Duluth harbor.

PROFESSIONAL PAPERS

There are to be three professional sessions at the St. Paul-Minneapolis Meeting as listed in the program published in this number. Advance copies of the papers assigned to these sessions have been printed for distribution and for use at the meeting. Those desiring copies in advance of the meeting are requested to notify the Secretary. After the meeting the papers and the discussion upon them will be published in The Journal. Brief abstracts of the papers follow herewith:

PULVERIZED COAL BURNING IN THE CEMENT INDUSTRY

By R. C. Carpenter

The paper treats of the development of the process of burning pulverized coal in the Portland cement industry and points out the underlying principles which control the process. It also gives a brief description of the machinery needed for the operation.

The requirement of the successful burning of pulverized coal is ability to burn the coal particles while in suspension. The process has always proved inefficient or a failure when the coal particles could not be kept in suspension during the entire process of combustion. This fundamental requirement makes it obvious that to obtain the very best results the coal should be ground very fully and also that the combustion furnace should be of favorable form. The cement rotary kiln is favorable for burning in suspension while the modern boiler furnace is not.

The paper describes the rotary kiln, dryers for removing moisture, various forms of pulverizing machines used in the industry and, as an example, a complete outfit for preparing the pulverized coal as adapted for a Portland cement mill. It also gives data as to the cost of pulverizing the coal and the production from the kilns.

PULVERIZED COAL FOR STEAM MAKING

By F. R. Low

Many attempts have been made to use pulverized coal as a fuel under boilers. Most of these have looked promising, but few have persisted, and a small proportion of the coal used for steam making is burned in this way. The paper mentions some of the earlier attempts and describes some of the systems upon which present effort is being expended. The proportionately large surface exposed by the finely comminuted fuel for oxidation makes perfect smokeless combustion with a minimum air supply possible. Combustion under such conditions, however, results in an unsupportable furnace temperature. If this is reduced by increasing the excess air, efficiency is sacrificed; if by reducing the amount of fuel fed, capacity is limited.

The overall advantage of this over the less expensive stoking methods in common use is yet to be proven.

INDUSTRIAL SERVICE WORK IN ENGINEERING SCHOOLS

By Joseph W. Roe

A live work has sprung up in the American engineering schools in the past six years, the object of which is to bring students into friendly contact with workmen while still in college, and to develop a feeling of confidence and goodwill on the part of both. About 3000 students in more than 100 engineering schools are engaged in it and are reaching about 50,000 men. The contact is mainly through teaching, principally in teaching English to foreigners as that is the most present need; but there are classes in other subjects, such as first aid to the injured, drawing, shop mathematics, civics, etc., as opportunity offers.

The work has proven of advantage to the workman, the student, the employer and the community. Typical instances are given of its working. It is not to be confused with regular settlement work, as one of its main objectives is the development of the student himself who is doing the teaching. Refined tools of production make possible high social development, but they by no means insure it unless they are directed in a spirit of fairness, goodwill and social responsibility. The development of this spirit is the object of the movement. It is suggested as an activity for the student branches of the Society.

CLASSIFICATION AND HEATING VALUE OF AMERICAN COALS

By William Kent

The paper gives the proximate and ultimate analyses and the heating values of 155 coals from different States, selected from the analyses of over 3000 coals published in Bulletin 22 of the U. S. Bureau of Mines. The selection was made in such a manner as to cover practically the extreme range of composition of the coals from the several States. A study of the relation of the heating value to both the ultimate and proximate analysis was made, and it was found that all the coals of the Appalachian field, cannel coals excepted, show figures of heating value per pound of combustible close to those derived from a curve showing the relation of the heating value to the volatile matter in the combustible, first published by the author in 1892, when the volatile matter is not more than 35 per cent of the combustible. For coals higher in volatile matter, and for Western coals generally, the heating value varies over a wide range and appears to have no relation to the volatile matter, each district having a law of its own. It is found, however, that with such coals the heating value is related to the amount of moisture left in the coal after air drying, and that the proximate analysis calculated to coal air-dry and free from ash forms a basis for estimating the heating value of a coal with as near an approximation to accuracy as is given by Dulong's formula applied to the ultimate analysis.

The author proposes a new classification of coals, based upon proximate analysis and upon heating value, giving seven classes, as follows:

I Anthracite	IV Bituminous, high grade
II Semi-anthracite	V Bituminous, medium grade
III Semi-bituminous	VI Bituminous, low grade

VII Sub-bituminous and lignite

Classes I, II and III are the same as in earlier classifications, the semi-bituminous coals containing between 15 and 30 per cent of volatile matter in the combustible. Classes IV, V and VI have heretofore been considered as a single class, but they vary greatly in heating value and in the amount of moisture remaining in air-dried coal, which is

used as the basis of the subdivision into three classes. Class VII includes the two classes sub-bituminous and lignite of the U. S. Geological Survey, which are differentiated one from another by color, texture and disintegration by weathering, but not by heating value or by analysis.

THE RAILROAD TRACK SCALE

By W. W. Boyd

The present use of cast iron or steel levers requires too much metal to obtain the necessary strength which is required in this rough service; structural shapes are suggested, because of elimination of costly patterns, lightness, ease of fabrication, etc.

All knife edge seats should be machined to insure accuracy, also knife edges are to be ground to true, straight edges.

Weigh bridges are to be made sectional, to avoid objectionable bending over the supports, such as occurs in the use of continuous beams. In order to protect the knife edges, the load should be applied as near the middle of the end span as is possible.

To insure accuracy under all conditions of loading the levers must be made stiff enough to resist undue deflection. Deflection in the levers destroys the accuracy of the scale; the less spring, the more accurate and sensitive a scale will be. Further, the fewer levers used, the more sensitive and accurate the scale.

Following out the idea of stiffness in the levers, the maximum load that may come upon the weigh bridge must be considered, not as a load uniformly distributed, but as it actually exists, a concentrated load applied to the rail through the wheels and acting at the point of contact.

Some form of relieving mechanism should be used to lift the weigh bridge free from the knife edges and allow locomotives, etc., to pass over the weigh bridge with freedom, in preference to a dead rail.

Scales should be tested each month, and oftener, to insure continued accuracy. It is remarkable how little attention is given to this very important matter.

GEAR TESTING MACHINE

By Wilfred Lewis

A brief description of a gear testing machine which is the result of the author's efforts to realize in a concrete form an ideal machine for the purpose of continuing the experiments upon the strength of gear teeth reported to the Society by Professor Guido H. Marx at the Annual Meeting in 1912. The machine is the same in principle as that developed by the author and used by the Committee on Standards for Involute Gears, in tests upon gear wheels. It is designed to put a working load upon the teeth without consuming an excessive amount of power. The constructive features are new, however. The driving gear or the pinion mates with two gears rotating about the same axis. One of the driven gears is attached to the end of a hollow shaft and the other to the end of a solid shaft, passing through the hollow shaft and concentric with it. The load is applied by a pneumatic cylinder which produces a torsional movement between the two concentric shafts on which the two driven gears are placed. This causes one of the two gears to press against one side of the pinion teeth and the other to press against the other side. The pinion thus becomes in effect a driver and a driven gear. The power required to drive the apparatus with the gears loaded through the pressure of the pneumatic cylinder is only that required to overcome the friction of the teeth and of the journals.

A FLOW METERING APPARATUS

By A. M. Levin

The paper describes an apparatus for the measurement of fluids in closed channels. This consists of an ordinary elbow or bend, properly calibrated and provided at its outer and inner curved walls with suitable pressure-ports through which the pressures at these points may be transmitted to an ordinary U-tube manometer. Instead of determining the velocity of the fluid from its inertia pressure, as in the pitot tube and venturi meter, it is proposed in the flow-bend to utilize as a gage the centrifugal pressure exerted in deflecting the course of the fluid through a definite path. The centrifugal action of the moving mass depending on its true angular velocity only, eddies and whirls in the body of the fluid itself will but nominally affect the pressure registered at the pressure ports.

The various formulae relating to the flow-bend are the same as the corresponding ones relating to the pitot tube, but are prefixed by a multiplier which depends on the ratio of the diameter or width of the channel to the mean radius of curvature of the bend. The pressure difference between the two sets of pressure ports is, for equal velocity, ordinarily one and one-half times to twice the pressure difference shown by the pitot tube.

Many of the facts relating to the flow bend which its theory evidently brings out are amply corroborated by practical test.

POWER DEVELOPMENT AT THE HIGH DAM BETWEEN MINNEAPOLIS AND ST. PAUL

By Adolph F. Meyer

The project for the improvement of the Mississippi River between Minneapolis and St. Paul had its inception in 1866. No definite action was taken, however, until 1894, when plans were developed for two locks and dams about 13 ft. lift each, to facilitate navigation. There finally developed the construction of the present High Dam on the site of the proposed low dam No. 1, with a head of over 30 ft. by which means 15,000 to 20,000 h.p. would be generated in addition to the effect which the dam would have upon the river for navigation purposes. As a result of state legislation there has been incorporated the Municipal Electric Company composed of the State University of Minnesota, and the cities of Minneapolis and St. Paul which, in the event of favorable congressional action, will lease the available water power from this dam.

The paper takes up the preliminary features which were studied when the project was developed with regard to the extent of the water supply, the effect of pondage and the power available. It then discusses the economical size of installation under the conditions to be met and describes the installation which was finally proposed. Data are given

upon the cost of developing the water power, including fixed charges and operating cost.

The known uses for which the Municipal Electric Company will supply power give a definite indication of the present and future consumption of this power, a study of which completes the power problem involved in the High Dam development. The concluding portion of the paper takes up the various factors involved in the utilization of this power.

THE HANDLING OF COAL AT THE HEAD OF THE GREAT LAKES

By G. H. Hutchinson

The shipment of coal to the Northwest by way of the Great Lakes began as far back as 1855, when about 1414 tons passed through the Soo Canal. Little, if any, of this was taken to Duluth and Superior, as the bulk of it went to the copper country in Michigan. In 1871 E. N. Saunders, for many years president of the North Western Fuel Company, arranged for the first shipments of commercial coal to Duluth, amounting to 3000 tons the first year. In 1913 the total tonnage passing through the Soo Canal was nearly 80,000,000 tons, of which about 20 per cent was coal.

This paper traces the development of coal handling apparatus during this period, with special reference to the equipment at the Head of the Lakes. It is illustrated by many diagrams and photographs. It also discusses the transfer of coal at the lower lake ports from cars to boats. A historical treatment is given of the arrangement of the docks for receiving, stocking and re-shipping coal at the receiving ports, with a description of the improvements made from year to year in the machinery for handling coal. Data are given with regard to the first electric coal-handling plant installed for the North Western Fuel Company, with which is compared a late installation comprising the first electrically operated man trolley coal bridge, showing the tendency toward the use of large units within the past few years. Features relating to the practical operation of the apparatus are outlined, such as screening, trimming, weighing, avoidance of breakage and spontaneous combustion, safeguarding of employees, etc.

MINNEAPOLIS FLOUR MILLING

By Charles A. Lang

The paper describes the development of milling in Minneapolis with reference to the water power and the modern milling process. The first mill built there in 1823 was a crude affair and in the early days of the industry there was much rivalry. The later developments have been in the direction of the increase of capacity and the improvement of milling systems rather than of building new mills. The present output is 84,000 bbl. of flour a day. The power is furnished by the Falls of St. Anthony, practically all of the 60,000 h.p. of which is consumed by them.

One of the American contributions to milling developed in Minneapolis is the purifier, a reciprocating sieve over which passes certain of the streams of mill stock and through which is drawn a current of air which removes the dust that would cause discoloration in the finished flour. In the Hungarian or gradual reduction process the wheat passes through numerous grinding operations in series before its final reduction to flour and it is the means by which clean white flour is produced. The color of finished flour is obtained by granulation.

Wheat obtained from different sections is by no means the same in characteristics or quality, but the flour produced must be. The modern mill has a well-equipped laboratory for testing various kinds of wheat.

The paper concludes with a detailed description of the milling process.

TRANSPORTATION ARRANGEMENTS

SPECIAL TRAIN TO BE PROVIDED BETWEEN CHICAGO AND ST. PAUL

A special train on the Chicago, Burlington & Quincy Railroad, leaving Chicago Monday evening, June 15th, at 10:45 o'clock, will convey the members to St. Paul

Bluffs Near Lynxville, Wis., on Bank of Mississippi

where they will arrive Tuesday afternoon, at 3:30 o'clock.

The route traveled is the main line of the Burlington Railroad, from Chicago to the Twin Cities. From Savanna, Illinois, for the distance of 300 miles to St. Paul, the train skirts the east bank of the Mississippi, with its beautiful scenery dotted by picturesque villages, many of them founded by Italian, German and Yankee pioneers long before the advent of the railroad. The train schedule has been so arranged as to enable the members to pass through the more interesting section of the trip by daylight.

The special train provided will have a very high grade of equipment, combining safety and comfort with punctuality. There will be standard drawing room and compartment sleeping cars and a large steel dining car, lighted by concealed indirect lighting and having many new and unusual conveniences, will be attached. The train will also include a lounge-observation car of luxurious type, with smoking room and

buffet annex, large lounging parlor, writing alcove and library. At the rear of the car is a sun parlor having broad plate glass windows which may be removed in a short space of time, creating an open car. The train will be electric lighted from the head end by a 64-volt, 25-kw. Curtis turbo-generator, which will be in charge of an expert who will demonstrate its operation. A

Mississippi River and Three Sisters Mountain

dynamometer car in full operation will be attached to the train, showing how the various tests records on railroads are taken automatically.

Three stops en route have been planned. The first of these will be made at De Soto, Wis., on Tuesday morning, from 6.30 to 7.30, for the observation of the rebuilding and double tracking now being done on this line. Much of the work is being accomplished by a dredging process never before used, and one of these dredges in operation, working from the river to the railroad, will be seen at this point.

At Grand Crossing, Wis., another stop will be made from 8.55 to 9.40 a.m. Here a large non-articulated locomotive, said to hold the record for economical operation, will be on exhibition. This engine is equipped with an automatic stoker, firing slack coal, and has a record of hauling 85 cars, 5812 gross tons, over a division having a $^{3}/_{10}$ per cent grade.

At a quarter past eleven the train will make a stop for three hours at Pepin, Wis., to enable the party to enjoy the beauties of Lake Pepin, which is a natural broadening of the Mississippi River, 3 miles wide and 22 miles long. Among the events planned are motor boat rides on the lake and short automobile tours into the surrounding country. A large government pier located on the lake is also an interesting feature.

For the assistance of members who will attend the Spring Meeting from the East, the following schedule of trains which will insure connections with this special train at Chicago is offered:

N. Y. C. & H. R. R. R. CO.

Lv. New York..6.45 p.m.	Arr. Chicago..5.00 p.m.	Fare, $25
Lv. New York..2.00 p.m.	Arr. Chicago..5.00 p.m.	Fare, $20
Lv. New York..5.00 p.m.	Arr. Chicago..2.00 p.m.	Fare, $26

P. R. R. CO.

Lv. New York..2.06 p.m.	Arr. Chicago..5.00 p.m.	Fare, $20
Lv. New York..5.04 p.m.	Arr. Chicago..2.00 p.m.	Fare, $26
Lv. New York..6.04 p.m.	Arr. Chicago..8.54 p.m.	Fare, $20

For a party of ten or more a reduction of $1.85 on the fare quoted will be made. The cost of sleeping reservations on any of these trains is at the rate of $5 for the lower and $4 for the upper berths.

The railroad fare from Chicago to St. Paul is $8.05, while the cost of sleeping accommodations is as follows:

Lower Berth	$2.00	Section	$3.60
Upper Berth	1.60	Compartment	5.00
Drawing Room	$7.00		

Request for reservation on special train should be made to P. S. Eustis, Passenger Traffic Manager, C., B. & Q. R. R., 547 West Jackson Boulevard, Chicago. As space will be reserved in the order of receipt of request, it is desirable to make early arrangements.

River and Islands at De Soto, Wis., Where Stop Will Be Made En Route

The Pennsylvania Railroad lands its passengers in Chicago at the Union station, from which the special train on the C., B. & Q. R. R. starts. A through ticket from New York to St. Paul includes a coupon covering free transportation of passenger and hand baggage be-

tween any two stations in Chicago. Trunks are checked through to destination, also without charge for transference across the city.

HOTEL ACCOMMODATIONS

The St. Paul Hotel, St. Paul, Minn., will be the headquarters for the Spring Meeting and all sessions in St. Paul will be held there. Requests for reservations should be made direct to the hotel management.

Accommodations can also be secured in St. Paul at the Hotel Ryan.

In Minneapolis the hotels suggested are the Plaza on Hennepin Avenue, the Leamington on 9th Street and Third Avenue, South, and the Dyckman, on 6th Street, near Hennepin Avenue.

The rates per day for room and bath are as follows:

HOTEL	SINGLE OCCUPANCY	DOUBLE OCCUPANCY
St. Paul	$2—$5	$3—$6
Hotel Ryan	$2—$3	$3—$5
Leamington	$2	$3
Dyckman	$2 upwards	$3 upwards
Plaza	$2—$3 $5 (Suite of two rooms) $8 (Suite of three rooms)	

CURRENT AFFAIRS

During the past month the President and Secretary of the Society have attended a number of meetings of engineers in local centers, some under the auspices of the local Committees on Meetings of the Society and others in which they coöperated with other members of the engineering profession. Accounts of those conducted by the members of the Society are given in another section of The Journal.

Both Mr. Hartness and Mr. Rice were guests of honor at the dinner of the Providence Mechanical Engineering Association and of the Society held in Providence on April 29. On April 30 they returned to New York, especially to bid a bon voyage to Ambrose Swasey, Past-President of the Society, who sailed for Germany on the Victoria-Luise, which a little less than a year ago conveyed the large party of the members and their guests who attended the meeting with the Verein deutscher Ingenieure. While abroad Mr. Swasey will extend the invitation of the engineering profession of America to the engineering societies of the world to attend the Engineering Congress in San Francisco in 1915, particularly the Verein deutscher Ingenieure, the Société des Ingénieurs Civils de France, and the Institution of Mechanical Engineers of London. Mr. Swasey will return about July 1.

On May 13 the President and Secretary attended the last meeting of the season of the membership in the vicinity of Chicago. Each of the four meetings held has been in connection with an informal dinner and has proved very successful, affording an opportunity for the development of acquaintanceship as well as to hear an address of technical interest. The attendance has averaged over 200. The Secretary spoke of the opportunities which membership in the Society offered for rendering service to the profession, and said that the real benefits from membership in any organization are in proportion to what the member puts into it, not what he gets out of it.

The Secretary attended the rally of the Engineers Society of the State of Pennsylvania in Harrisburg on May 15, but the President was unable to be present. The invited guests included also P. M. Lincoln, president-elect of the American Institute of Electrical Engineers, and Chas. Enzian, vice-president of the Engineering Society of Northeastern Pennsylvania, as well as a member of the American Institute of Mining Engineers and of the American Society of Civil Engineers. Remarks were also made by several of the past-presidents of the Engineers Society of the State of Pennsylvania. The topic of the evening was the opportunities for coöperation between the engineering societies of the State of Pennsylvania, and between state and national societies, and an address was made by Dr. John Price Jackson, president of the entertaining organization.

Although unable to attend the meeting of the Milwaukee members on May 13, the Secretary held a telephone conversation with the Secretary of the Milwaukee Section and was pleased to hear of the success of the meetings.

The Engineers Club of Dayton, Ohio opened their new club house with a housewarming on May 14, but both the President and Secretary found it impossible to be present. The movement for organization in that city, instituted about a year ago, has met with enthusiastic coöperation, and the club is to be congratulated on its initial meeting.

CALVIN W. RICE, *Secretary.*

ENGINEERING CONGRESS IN 1915

A committee on reception to the foreign engineers who have been invited to visit the Engineering Congress in San Francisco in 1915, has been appointed as follows, and includes representatives of the five national engineering societies: H. H. Barnes, Jr., Alex. C. Humphreys, Charles Warren Hunt, Geo. F. Kunz, W. M. McFarland, E. D. Meier, E. E. Olcott, W. L. Saunders, Geo. F. Sever, and Stevenson Taylor.

COUNCIL NOTES

At the meeting of the Council on May 8 it was voted as a mark of the Council's respect and appreciation to leave unfilled until the next election the office of Manager, made vacant by the death of Alfred Noble. Wm. H. Wiley, Jesse M. Smith and F. R. Hutton were appointed a committee to prepare suitable resolutions.

The Committee on Standardization of Catalogue Sizes presented its revised report and was discharged with thanks. CALVIN W. RICE, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the membership by advising the Secretary promptly of anyone whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before July 10, 1914.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

AYER, LUTHER S., Factory Mgr., International Motor Co., Plainfield, N. J.

BEHR, FRANCIS J., Government Representative, Hammond Radio Research Laboratory, Gloucester, Mass.

BILTON, CLARENCE E., Pres. and Treas., The Standard Mfg. Co., Bridgeport, Conn.

BURR, FRANK A., District Representative and Mech. Engr., Spray Engrg. Co., Chicago, Ill.

CAMPION, NORMAN G., Mill Supt., Calamba Sugar Estate, Canlubang, P. I.

CHAMBERS, NORMAN C., Representative Engr., Foreign Dept., Niles-Bement Pond Co., New York.

COLE, ROBERT C., Elec. Engr., Johns-Platt Co., Hartford, Conn.

CROSS, WALLACE J., Asst. Ch. Engr., Lake Superior Corp., Ltd., Sault Ste. Marie, Canada

DOUD, WILLARD, Mech. and Elec. Engr., Chicago & Western Indiana R. R. Co., Chicago, Ill.

DRAKE, CHARLES F., Babcock & Wilcox Co., Chicago, Ill.

DUNCAN, JOHN C., Prof. of Business Administration, University of Cincinnati, Cincinnati, Ohio.

FEYBUSCH, MARTIN, V.-P. and Treas., Jagenburg Mch. Co., Inc., New York

FLETCHER, FRED, District Sales Engr., Corrugated Bar Co., Buffalo, N. Y.

FULLERTON, WM. J., Supt., Helderberg Cement Co., Howes Cave, N. Y.

GIBBS, HAROLD E., Erecting and Testing Engr., Snow Steam Pump Wks., and Holly Mfg. Co., Buffalo, N. Y.

GLEASON, KATE, Secy., Gleason Works, Rochester, N. Y.

GORDON, WM. J., Mech. Supt., International Milling Co., New Prague, Minn.

GOULD, WM. S., Pres., Fuel Engrg. Co. of New York, New York

HAMMERS, MORGAN J., V.-P. and Engr., Abbott Motor Car Co., Detroit, Mich.

HOLMES, WINFIELD E., Engr., Samuel M. Green Co., Springfield, Mass.

HOWARD, DAVID C., Pres., DeLaney Forge & Iron Co., Buffalo, N. Y.

INGRAHAM, CARL L., Head Engr., Denver City Tramway Co., Denver, Colo.

KENDALL, HENRY P., Treas. and Genl. Mgr., The Plimpton Press., Norwood, Mass., and Pres., Lewis Mfg. Co., Walpole, Mass.

KEETH, GROVER, Asst. to Mech. Engr., Public Service Co. of Northern Ill., Chicago, Ill.

KING, ARTHUR D., Asst., Engrg. Dept., Standard Plunger Elevator Co., Worcester, Mass.

LAGE, GEORGE, Pres., Cia Nacional de Navegacao Costeira, Rio de Janeiro, Brazil

LANGELIER, ANTOINE J., Pres. and Designing Engr., Langelier Mfg. Co., Providence, R. I.

LOSEY, JOHN B., Supt., Amphion Piano Player Co., Syracuse, N. Y.

MAHER, EUGENE E., Pres., Maher & Byrne Co., Chicago, Ill.

MAY, OSCAR J., Lubricating Expert, The Texas Co., Chicago, Ill.

MORGAN, HENRY, Mech. Draftsman, Lehigh Coal & Navigation Co., Lansford, Pa.

NELSON, ALFRED C., Mech. Engr., with Arthur G. McKee, Cleveland, Ohio

PABODIE, ROBERT J., Wks. Mgr., The Griscom Russell Co., Massillon, Ohio.

PATTISON, HUGH, Elec. Engr., Com. of Investigation on Smoke Abatement, Chicago, Ill.

RICHARDSON, MAURICE F., Operating Mgr., The Arlington Co., Arlington, N. J.

ROESTI, PAUL G., Designer, Sulzer Brothers, Winterthur, Switzerland.

SEAVER, KENNETH, Ch. Engr. and Asst. Genl. Sales Mgr., Harbison-Walker Refractories Co., Pittsburgh, Pa.

SIDNEY, PHILIP, Singer Mfg. Co., 149 Broadway, New York

STEINMETZ, JOSEPH A., Member of Firm, Janney, Steinmetz & Co., Philadelphia, Pa.

STEVENSON, BARTON, Sales Mgr., Cleveland District, Westinghouse Mch. Co., Cleveland, Ohio.

THOMAS, GEORGE B., Mech. Engr. and Designer, The Bryant Elec. Co., and The Perkins Elec. Switch Mfg. Co., Bridgeport, Conn.

THOMAS, FIELDER W., Efficiency Engr., Plant of The Globe-Wernicke Co., Norwood, Ohio

WADSWORTH, ARTHUR V., Supt., Buckeye Traction Ditcher Co., Findlay, Ohio.

WENDLAND, CHARLES F., Pres., Mgr. & Cons. Engr., C. F. Wendland Engrg. & Constr. Co., New York.

WILLIAMSON, CHARLES S., Western Mgr., Mead-Morrison Mfg. Co., Chicago, Ill.

WILDE, ROBERT, Consulting Gear Engr., with Warner Gear Co., Muncie, Ind.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Blake, Alfred D., Associate Editor, "Power," New York

Boyle, Clarence, Jr., Taylor-Wharton Iron & Steel Co., Scranton, Pa.

Cordes, Paul H., Engrg. Representative, International Steam Pump Co., Chicago, Ill.

Doble, Ralph N., Mech. Engr., Pneumatic Scale Corp., Ltd., Norfolk Downs, Mass.

Dowd, John H., Efficiency Investigator, Royal Typewriter Co., Hartford, Conn.

Gale, Warren D., Experimenting with Rotary Valve Gas Engines, Waterville, Canada.

Hastings, Glen B., Western Representative, The Tabor Mfg. Co. of Phila., Chicago, Ill.

Haynes, Edward A., Genl. Mgr., Port Huron Paper Co., Port Huron, Mich.

Hughes, Henry M., Mech. Engr., Franklin Steel Works, Franklin, Pa.

MacNabb, Arthur W., Engrg. Dept., Fidelity & Casualty Insurance Co., New York.

Marshall, Wm. E., Instructor, Stevens Institute of Technology, Hoboken, N. J.

Robert, Lawrence W., Jr., Member of Firm, Park A. Dallis Co., Atlanta, Ga.

Robinson, Kenneth C., Asst. Instr., Mass. Inst. of Tech., Boston, Mass.

Stee, Reuben M., Engr. and Representative, Canadian Fairbanks Morse Co., Winnipeg, Canada

Swallow, Howard J., Rate and Estimating Depts., Newark Wks., Westinghouse Elec. & Mfg. Co., Newark, N. J.

Van Brunt, Edmund S., Draftsman and Designer, Isthmian Canal Commission, Culebra, C. Z.

Whitall, Roy C., Engr., Whitall Elec. Co., Westerly R. I.

FOR CONSIDERATION AS JUNIOR

Fehr, Roy B., Instr. in Mech. Engrg., The Pennsylvania State College, State College, Pa.

Hahn, Conrad V., Instr. in Engrg., University of Pennsylvania, Philadelphia, Pa.

Harris, Wm. B., Student in Mech. Engrg., Mass. Inst. of Tech., Boston, Mass.

Shattuck, Charles H., Representative, C. F. Braun & Co., San Francisco, Cal.

Smith, Alvin L., Asst. Instr. in Mch. Design, Sheffield Scientific School, New Haven, Conn.

Stork, Wilford L., Student, Columbia University, New York

Toney, Perry S., Draftsman, Lincoln Telephone & Telegraph Co., Lincoln, Neb.

Trump, Charles C., Secy., Humphrey Gas Pump Co., Syracuse, N. Y.

Zouck, George H., Supt., Key Highway Paving Contract, Consolidated Engrg. Co., Baltimore, Md.

APPLICATIONS FOR CHANGE OF GRADING

TRANSFER FROM ASSOCIATE

McBane, Walter W., Engr., The Wm. Tod Co., Youngstown, Ohio

Warren, Walter B., V.-P., Warren Brothers Co., Portland, Ore.

PROMOTION FROM JUNIOR

Barron, Claude M., Cons. Engr., R. W. Cameron & Co., New York

Bateman, George W., Genl. Purchasing Agent, Sullivan Mchy. Co., Claremont, N. H.

Brown, Eugene L., Jr., Chief Deputy Inspector, Boilers, Elevators and Smoke Abatement, City of St. Louis, Mo.

Domonoske, Arthur B., Instr. in Machine Design, University of Illinois, Urbana, Ill.

Doolittle, Warren P., Head Mch. and Tool Designer, The Waterbury Mfg. Co., Waterbury, Conn.

Eager, Wm. G., Second V.-P., Valdosta Lighting Co., Valdosta, Ga.

Ernst, Alfred F., Engr., Brighton Mills, Passaic, N. J.

Hind, Robert R., Ch. Factory Engr., Ewa Plantation Co., Ewa, Hawaii

Hook, James W., Sales Mgr., C. A. Dunham Co., Marshalltown, Iowa

Jenks, Glen F., Captain, Ordnance Dept., U.S.A., Sandy Hook Proving Ground, Fort Hancock, N. J.

MacGregor, Wallace F., Supt., of Experimental Dept., J. I. Case Threshing Mach. Co., Racine, Wis.

SUMMARY

New applications	72
Applications for change of grading	
Transfer from Associate	2
Promotion from Junior	11
Total	85

SYMPOSIUM ON WELDING AT BOSTON

At the March meeting of the Society at Boston a symposium was held on Welding topics, the four papers presented representing the processes of welding most generally used in industrial work, namely: welding with oil fuel, oxy-acetylene welding, thermit welding and electric welding. The speakers were as follows: W. N. Best, oil furnace specialist, of New York; Henry Cave, president of the Cave Welding Company, Springfield, Mass.; W. R. Hulbert, sales manager, Goldschmidt Thermit Company, New York; and W. A. Hodges, treasurer, Thomson Electric Welding Company, Lynn, Mass. The papers presented appear in abstract form below:

THE WELDING OF METALS WITH LIQUID FUEL

By W. N. Best, New York

Member of the Society

The oil burner should be able to thoroughly atomize any gravity of liquid fuel procurable in the open market, such as crude oil, fuel oil or tar. It is now well known that very heavy low gravity crude oil must be used, for this is the cheapest fuel, because it contains so little gasolene or other volatile matter that it does not pay to refine it. This oil at present is procured largely from Mexico, where the supply appears to be practically unlimited, but when the Panama Canal is completed, a great deal of heavy California crude oil of from 14 to 16 gravity Baumé will be delivered to the manufacturing interests along the Atlantic coast. While it is necessary to heat heavy oil to reduce its viscosity, this is a very simple matter.

The burner should be of such construction that it will not carbonize, and it should distribute a volume of flame and heat evenly throughout the entire charging space of the furnace without the use of brick or spatter walls. One of the secrets of success lies in having the furnace construction in every detail adapted to the work. In other words, to heat 8 in. or 9 in. of metal when a 3-in. heat is ample is very poor shop practice, for it means a loss of both time and fuel. Other vital points which must be considered are: the furnace construction should be such that the heat is evenly distributed and under the control of the operator at all times: the temperature of the metal should be uniform throughout the length and width of the sections to be welded; furthermore, the nature of the metal should not be changed while being welded, and the oxidization of the metal should be reduced to the minimum.

In welding safe ends on locomotive boiler flues, the usual practice when using soft coal as fuel, is to have one blacksmith and two helpers, it being the duty of one helper to bring the flue from the pile to the smith who heats it and of the second helper to rush it to the flue welding machine where it is welded. The average time required for thus safe-ending flues is 16 flues per hour, for the fire must be coked before a weld can be made, which means not only a loss of time, but also an irreparable loss in fuel for it requires both time and heat to liberate the gases from the coal. Modern practice is now to use an oil fired furnace of special design such as shown in Fig. 1, which insures a very short heat, approximately only 2½ in. long, and the heating of three flues at once. This furnace has a combustion chamber in which the atomized fuel unites with the air necessary for perfect combustion, which prevents

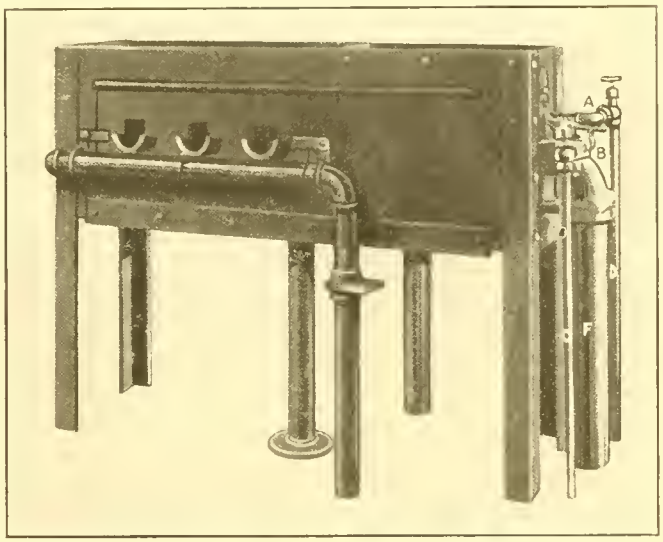


Fig. 1 An Oil-Fired Furnace for Welding Boiler Flues

oxidization of the metal while being heated, and as no sand or borax is required, 60 flues are welded per hour with exactly the same number of men as are used while welding 16 flues with a coal fire. The average welding machine is fully adequate to keep pace with such an oil fired furnace. Imperfect welds with this scientific method of operation are so few that it does not pay to give a water test to each flue, but when using coal as fuel this must always be done, for often the exterior of the weld will look perfect but it will be found to leak badly, because the sulphur in the coal corrodes the metal.

In welding scrap iron, a quantity of scrap is ordinarily piled upon a board, wired thereto and charged into a furnace such as is shown in Fig. 2. After being

heated in the usual manner, it is either hammered to size or rolled into billets in a breakdown mill. The use of oil as fuel for this class of work has the advantages that, first, a more even heat can be attained and maintained in the furnace than with any other fuel; second, the temperature of the heat or charge is uniform throughout; third, if a cobble gets on the roll of the breakdown mill which it will take some minutes to remove and to readjust the guide, simply by increasing the amount of oil flowing to the burner, the gases in the furnace can be changed from a dioxide to a monoxide which instantly stops the waste of metal, and then after the cobble has been removed, the charge can be made ready to draw in a moment's time by reducing the oil supply which again instantly changes the furnace gases back to carbon dioxide (CO_2); fourth, a greater output can be obtained from this type of furnace with oil than with any other fuel upon the market because the operator has the fire at all times under perfect control. In the majority of furnaces for this class of work the waste gases, in the same way as when burning coal, are passed through a boiler which is used for the generation of steam.

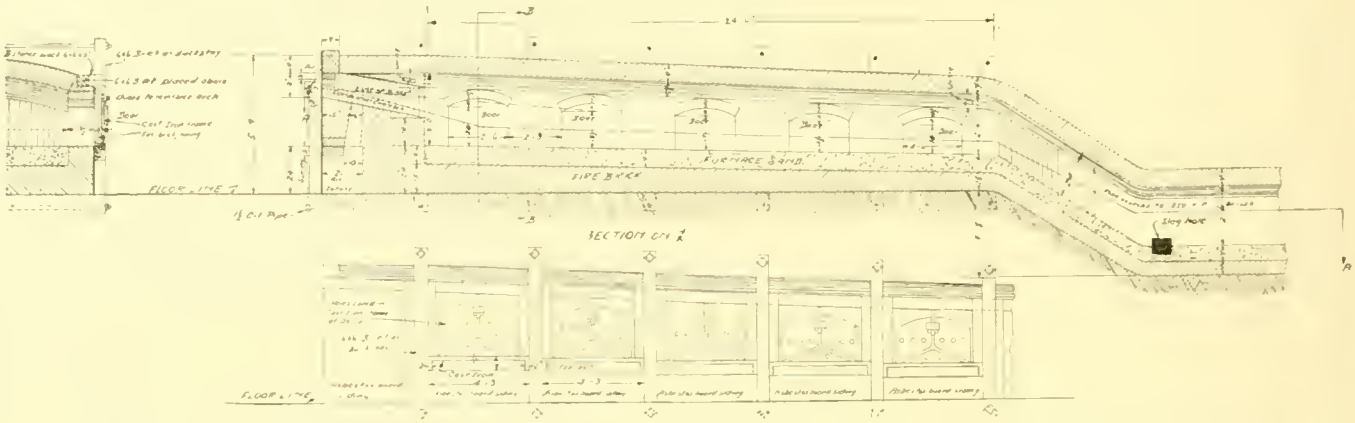


Fig. 2 An 8 Ft. by 24 Ft. Furnace, as used in Rolling Mills and Large Blacksmith Shops for Heating Scrap, fitted for Oil-Firing

Flange welding, such as the welding of flanges upon pipe, requires both skill and experience, and while oil is the ideal fuel as the heat can be evenly distributed without turning the pipe, the furnace construction is of vital importance. The furnace should be cylindrical in form, with a combustion chamber and burner so placed that the flame will enter the furnace tangentially, thus causing the flame and heat to encircle the flange and pipe (Fig. 3). The vents, through which the consumed and inert gases pass out of the furnace, must be so placed that they will not check the velocity of heat nor prevent the flange and pipe from being heated evenly in their circumference. This same furnace can also be used for "vanstoning" the ends of various sizes of pipe.

For forging purposes, oil is an excellent fuel, especially for large axles or shafts from scrap iron piles. The latter, after being heated, are hammered down into blooms say 5 in. by 20 in. by 5 ft. and ordinarily three blooms are used to forge an axle. Usually as many piles of blooms are charged into the furnace as there are doors. The piles are heated much more quickly with oil than with coal. It is a well-known fact that car or locomotive axles must be free from any defects such as seams or other flaws caused by imperfect welds, and as the use of oil as fuel means a 30 per cent reduction in the number of imperfect axles, it is of great benefit to both the employer and employee for it saves not only time and money but prevents wrecks.

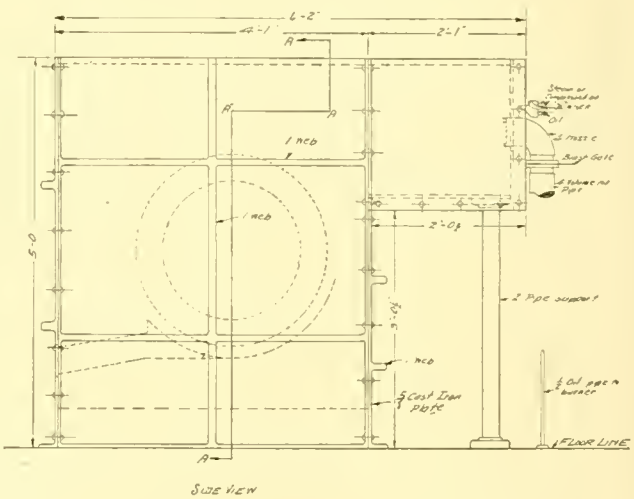


Fig. 3 A Pipe Welding Furnace used for Welding Flanges on Pipe, Operated with One Oil Burner

As before stated each class of work requires special oil equipment adapted to the size and kind of metal to be welded. For example, in welding wrought iron or soft steel to say 60 carbon steel, the construction of the furnace, as shown in Fig. 4, must be such that the flame will be delivered to the underside of the charge, thus deflecting the flame or abrasive heat upon the wrought iron rather than upon the carbon steel for the former requires the higher temperature. Of course in this case borax is used in making the weld and there should be a preheating chamber constructed in the fur-

nace so that the iron will be heated to 800 or 1000 deg. fahr. before the 60 carbon steel is laid thereon.

In the round house welding of broken locomotive frames (Figs. 5 and 6), the drivers are dropped in the usual manner, the break scarfed and an insert or "Dutchman" driven therein, after which a temporary furnace is constructed around the frame and a portable furnace then used to bring the frame up to welding heat. The blacksmith's work of welding the insert into the break can then be completed in a very few minutes. The time required for bringing the frame up to the welding temperature is approximately 40 minutes, and the quantity of oil varies from 2¼ gal. to 2½ gal.

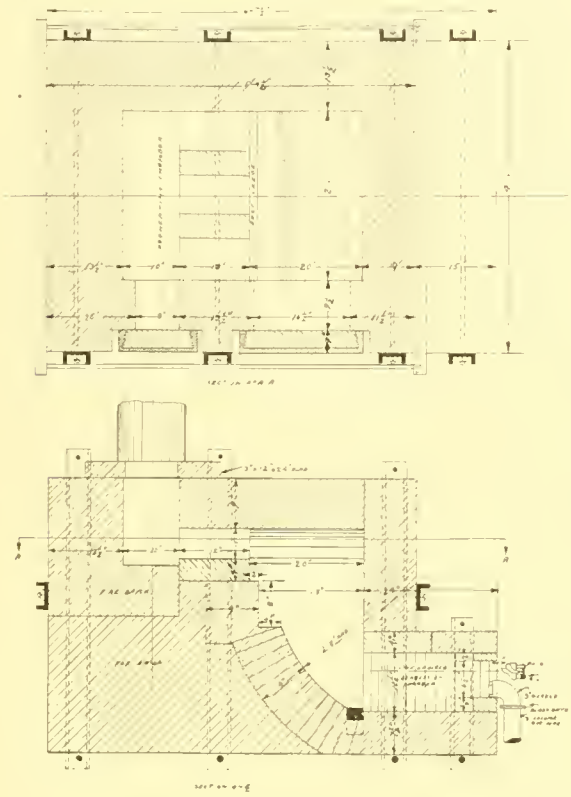


Fig. 4 Details of Special Oil Fired Furnace for Welding Wrought Iron and Soft Steel to 60 Carbon Steel

Fig. 5 Preparing Broken Locomotive Frame for Welding, showing Insert at A

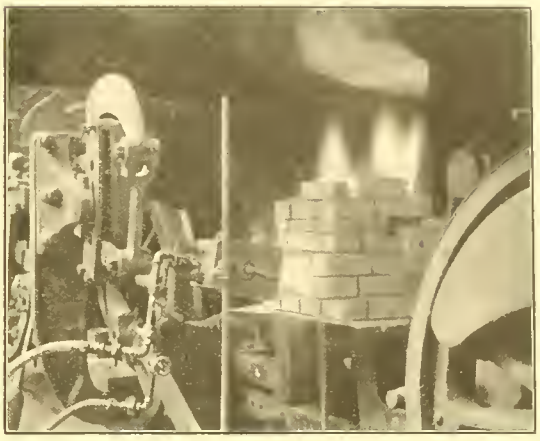


Fig. 6 View of Temporary Furnace in Place and Portable Oil-Burner in Action

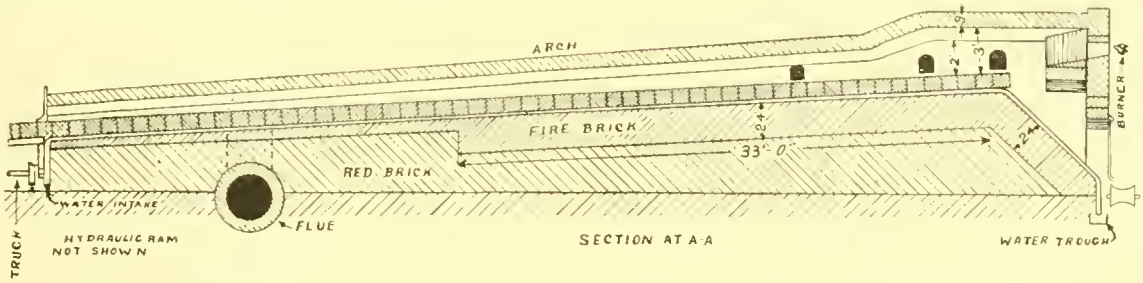


Fig. 7 A Continuous Type of Billet Furnace, as used in Wire Mills, fitted for Oil Fuel

The continuous type of billet heating furnace, shown in Fig. 7, is often used in wire mills. They are about 10 ft. in width and 70 ft. in length. Usually two rows of billets are charged in the furnace and of course the size of the billets varies according to the size of the wire or iron to be rolled, some being as small as 6 in. sq. by 3 ft. long, while others are 12 in. sq. and 4 ft. long. The billets are charged at one end and when sufficiently heated, by means of hydraulic rams placed in the charging end of the furnace, are dropped from the burner end of the furnace on to conveyors at the will of the operator. Having a furnace of this type insures the billets being heated gradually at a minimum cost of fuel. Only one burner is used on this furnace and the temperature is readily controlled by the operator.

THE OXY-ACETYLENE PROCESS OF WELDING

By Henry Cave,[1] Springfield, Mass.

Non-Member

Autogenous welding is a general term given to welding when metal fuses. In the ordinary blacksmith's weld the metal does not fuse; it becomes plastic and is hammered together, but unless hammered no weld would be produced.

Autogenous welding is carried out in several different ways, but as here referred to is by means of acetylene burned with oxygen. The use of oxygen with other combustible gases consisting of an oil gas similar to Pintsch gas termed "liquid" or "Blau gas" in this country, hydrogen and a few others are sometimes used, but are not efficient owing to limitations of temperature. The process using acetylene necessarily makes very much the hottest flame, owing to the large amount of carbon in the composition of this gas.

This process is an indirect development of electricity. Shortly after the electric furnace was developed, the general use of acetylene was made possible, calcium carbide, from which acetylene is generated, being made in the electric furnace. In 1895, shortly after the development of calcium carbide, Le Chatelier, the French scientist, proposed this process, that is, that the burning of acetylene with pure oxygen would produce a very high temperature. It was not, however, until 1905 that an equipment came into this country for practical use in a factory. From that time there has been a gradual development in the equipment and a rapid development in the uses for the process.

The acetylene is produced in a generator direct from calcium carbide, the gas passing through a reducing valve and hose that connects with the torch. If a welding equipment is to be used for portable work or work of an intermittent nature, acetylene is obtained from a dissolved acetylene cylinder as a source of supply, instead of from a generator, the other parts of the equipment being the same. The dissolved cylinders are not merely empty cylinders into which the gas is compressed as is the case with the oxygen cylinders, but contain a porous material, generally asbestos, into which is poured acetone or a similar liquid; the acetone absorbs the gas and the liquid is held in suspension, thus filling the cylinder at all times, and in that way it is perfectly safe under a high pressure. The gas is drawn off through a hose, as is also the oxygen from the other tank, and both are brought together in the torch.

The source of the oxygen in a general way is a cylinder of compressed gas. In some cases the compression is very high, up to 1800 lb. per sq. in., which high compression is for the sake of economical conditions of transportation. But in some cases it is used in low pressure cylinders (300 lb. per sq. in.) which are charged from generating equipment on the premises, or it may be generated and compressed directly into the service pipes by several different means. The chemical method of manufacture from chlorate of potash and manganese dioxide requires the cheapest equipment, but provides the most expensive gas, and is very little in use now. The electrolytic method of disassociating water into oxygen and hydrogen is coming very rapidly into use for large and small installations. Very large oxygen generating equipments have been installed throughout the larger cities of the country for making oxygen from the atmosphere by the liquid air process, the oxygen being distilled off from the liquid air.

The torches used in both welding and cutting work are provided with tips for producing different sizes of flames in each torch. That is the same as changing the size of flame in a gaslight by removing a burner and replacing it with a larger or smaller one, the variation of flame being required for welding different weights of material. The tip is made of brass, there being one hole through the center, the mixing arrangement where the oxygen and acetylene are mixed together in correct proportions being located at the inner end.

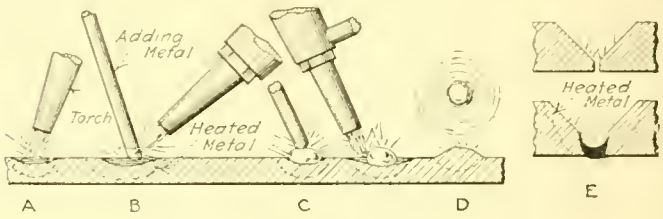


Fig. 1 Diagram showing Method of Making Typical Oxy-Acetylene Weld

In addition to the use of this process for welding, another operation of interest because of its connection with the oxy-acetylene process and that it is carried out with practically the same equipment, is the cutting of steel by means of oxygen. Cast iron and non-ferrous metals cannot be cut by oxygen, steel, wrought iron and cast steel being the only metals cut in this manner. I have known of considerable expense being undergone in attempts to cut cast iron, due to ignorance of this feature, the reason being, the free carbon in the iron stops the penetration of the oxygen. The cutting torch differs from those used for welding in that the tips have more than one hole; the central hole supplies the pure oxygen for cutting and the two outside holes are heating flames, identical with those used for welding.

The process of cutting steel in this way is a development of the old school experiment of inserting the red-hot end of a clock spring into a jar of oxygen, in which

[1] President, Cave Welding Company.

the red hot part of the clock spring began to glow and was gradually consumed, proving that steel would burn in an atmosphere of oxygen. The process is simply reversed in practice, in that the flame is applied to the piece of metal and a small spot heated, then the jet of oxygen is directed on that red-hot spot and the metal begins to burn; in burning it produces a slag of high temperature which, in flowing down the face of the part, is sufficient to heat the metal through a considerable depth (24 in. has been cut) so that the oxygen can combine with it. Thus the action is progressive, one layer being consumed heats the next one. It is not possible, however, to extinguish the heating flame as it is required to keep the molten slag fluid so that it will flow out of the cut; that is the only reason for keeping the combustion of the acetylene going while the cut is in progress after the first start is made.

This process of welding is not generally understood. There is a knack in making a strong weld, a knack that can be acquired only by the exercise of considerable judgment and practice. Fig. 1 shows the method of making a typical weld. The torch tip here carries a flame of 6300 deg. playing on the metal, and a pool of molten metal is first of all formed at *A*. The metal is heated up approximately as indicated by the shaded portion. Upon that spot is deposited a drop of molten metal from the rod of adding metal *B*, the end being fused into the melted pool *C*. The drop is then fused still further so as thoroughly to adhere it to the piece to which it is being welded, by playing the flame around that drop, until it assumes a shape as at *D*. With a sharp corner such as at *C*, no satisfactory weld would be produced, because there would be a spot on each side which could not be welded, but by playing the flame around a thorough weld right across would be obtained. The condition is very similar to the use of soft solder. Those familiar with it never trust work where the edges of the solder are rounded, but realize when they spread out to a thin edge the union is satisfactory. A succession of drops is put on in that way. These drops overlap each other, so a thoroughly strong weld is produced.

At *E*, Fig. 1, is a condition where parts are to be welded of considerable thickness. It should be stated that owing to the high temperature of the oxy-acetylene flame, a weld can be made from $\frac{1}{8}$ to $\frac{3}{16}$ in. in thickness without preparing the parts, that is, without beveling them out as shown at *E*. If it is a crack in a casting, it is chipped or ground out by means of some mechanical method, or if it is steel, it can be cut out by means of the oxygen jet and a groove formed. If it is attempted to make the weld from the outside without this groove, the metal would burn before its conductivity had time to convey the heat deep enough to make a weld of any depth.

With this process, the metal is first of all heated to red over a considerable area before any metal is added. The flame is then played at the bottom of the groove on the points of the prepared sections until they fuse together into one solid mass, and then additional metal is added. Thus the weld can be made completely through the parts. The additional metal is then built in and each drop fused to the side, producing a thoroughly homogeneous weld until the groove is filled up. This building up can be continued to any extent to reinforce the part at the weld or change its shape as desired.

The theory of the process of oxy-acetylene welding is shown in Fig. 2. A Davis-Bournonville high-pressure positive-mixture torch tip is shown at *A*. The acetylene, C_2H_2 passes in at the side orifices indicated and is ignited. When it is lighted in air a reaction takes place as shown (two and one-half parts of oxygen uniting with one part of acetylene yield carbon

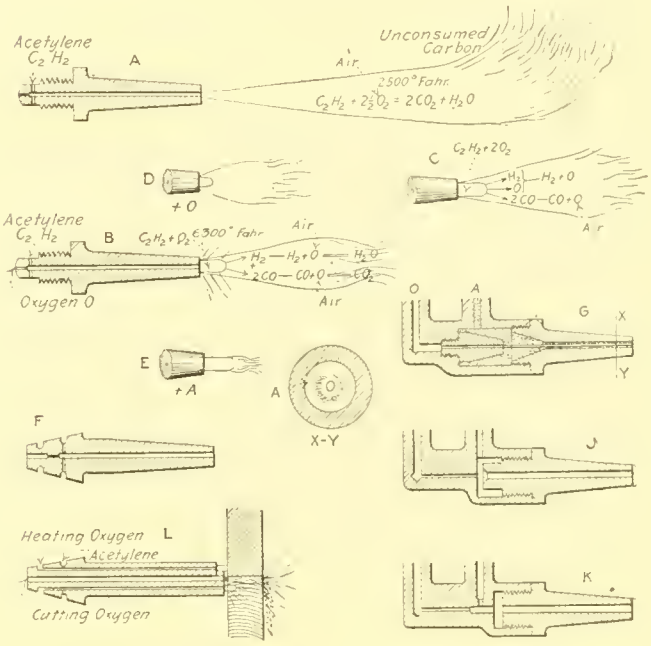


Fig. 2 Diagram explaining Theory of the Process of Oxy-Acetylene Welding

dioxide and water) and the reaction produces a temperature about the same as ordinary illuminating gas (about 2500 deg. fahr). The oxygen in this case is taken from the air; the fact that the air is only one-fifth oxygen is responsible for the fact that the gas has to spread out over a very large area to collect that one-fifth of oxygen, and also there is the four-fifths of nitrogen which is carrying the heat away needlessly. This heat is wasted and thus reduces the temperature of the flame. When the flame is burning, you will see that a considerable amount of unconsumed carbon is given off at the end of the flame, which shows that even then there is not sufficient oxygen for complete combustion.

When oxygen is supplied, from the cylinder or other source of supply of pure gas, passing in under pres-

sure at the small opening indicated at the end of the tip and striking the acetylene which is also under pressure, at right angles, a thoroughly homogeneous mixture is produced, and when a mixture of one part of oxygen and one of acetylene is provided by the size of the orifices, the reaction is as shown at *B*. (One part of oxygen uniting with one part of acetylene yields hydrogen and carbon monoxide.)

The high temperature of 6300 deg. fahr. is obtained in the bright cone immediately at the end of the tip. The hydrogen cannot burn in that high temperature zone as it cannot unite with the oxygen, because it is above the disassociation temperature of water. It therefore passes out to the long flame, which is called "the envelope," and burns to H_2O; neither can the carbon monoxide, the product of the first reaction, unite with the additional oxygen to produce carbon dioxide in the high temperature zone, and therefore this reaction must also take place in the envelope. The additional amount of oxygen is in both cases obtained

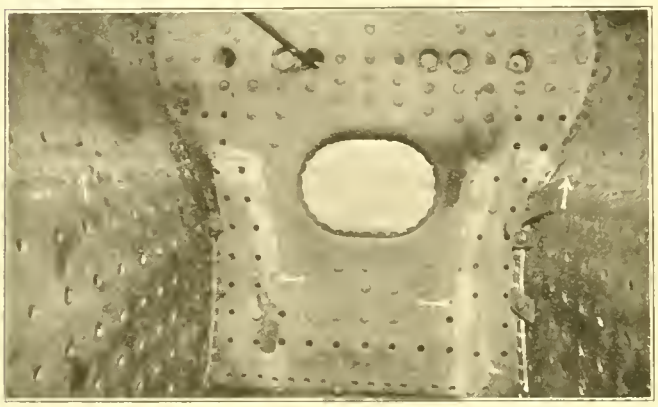


Fig. 3 View of Side Plates Welded in Place in Fire-box of a Locomotive

directly from the air if a satisfactory design of torch is used.

The carbureting arrangement in the torch which is generally at the base of the tip, corresponds to the carburetor of an automobile, and if it is not adequate or not of a good type, the mixture and reaction will not take place as given above. If too large a proportion of oxygen is supplied, this additional oxygen cannot possibly unite with a combustible element in the high temperature zone of this reaction because all the carbon is used up by one part of oxygen. Therefore the surplus must pass through to the envelope, and as shown at *C*, we have the reaction indicated (two parts of oxygen uniting with one part of acetylene yield hydrogen, carbon monoxide and a surplus of free oxygen).

Part of the surplus oxygen going to the envelope unites with either the hydrogen or the carbon monoxide and forms carbon dioxide or water vapor in the secondary reactions, so that a portion only of the oxygen required for these reactions is taken from the air instead of all of it; some of it is, in other words, taken from the source of supply, at a cost of $3\frac{1}{2}$ cents per cu. ft. (more or less, depending on conditions) instead of obtaining it from the air without cost, and that is obviously a very uneconomical condition.

If the means for bringing the oxygen and acetylene together are not such as will produce a vortex, and therefore cause all the molecules of oxygen to come in contact with the molecules of carbon in the acetylene, a certain proportion of the oxygen will pass out of the tip, and through the high temperature cone, unconsumed. Therefore to allow for this, a larger amount of oxygen must be supplied to obtain the normal adjustment of the flame which is distinguished by the clear outline of the inner cone. It can therefore be seen that this clear outline does not necessarily mean that the flame is neutral, as if the surplus oxygen is present as above, the flame must necessarily be oxydizing. The normal or ocular adjustment, as it might be called, therefore, may indicate a proportion of oxygen to acetylene of one to one (1.12 to 1 is the nearest to this that has been obtained) or it may indicate as high as two of oxygen to one of acetylene, 1.8 to 1 being very common.

If too large a proportion of oxygen is supplied through the tip for the normal setting as given above, the flame is shortened and the color is changed, *D*, as compared with *B*. The flame condition shown at *E* indicates too large a proportion of acetylene or a shortage of oxygen from the normal setting, the acetylene showing an extra or extended point on the bright welding flame. Those two extreme conditions are used by the operator to adjust his flame but he can only adjust it within the limits of the mixing device. This tip, *A* and *B*, is shown because it is a simple representation of the "high pressure positive mixture" carbureting device, but has now been changed to the form shown at *F*, the principle of which, however, is the same. The tip seats in a cone and the oxygen passes through the central orifice and the acetylene through the radial orifices, striking together so that there is no question of a thoroughly molecular contact of the gases being produced before they pass out and are ignited.

Another type of torch which is shown diagrammatically at *G* is that in which the two gases are brought together by what is termed the injector principle, oxygen passing in and shooting straight through a chamber which contains acetylene either under several pounds pressure or under only a few ounces. The conditions are practically the same in both cases. The oxygen shoots through and the capillary attraction or "skin friction" of the oxygen draws in the acetylene and produces a condition in which there is pure oxygen in the center and pure acetylene around the outside, with the mixture in a zone between the two as shown in section *XY*. It is well known that the injector is made just as smooth as possible inside, so as not to produce any vortex; also that an automobile car-

buretor will not work satisfactorily unless the gases are thoroughly mixed together. The same applies to a torch. This torch is made in various styles. Sometimes the injector cone is a narrow passage and sometimes quite a large area; there are frequently jogs or enlargements in the passage with the idea of producing mixing effects. All the gas, however, passes through the center of them.

Another type of tip is shown at *J*. This differs only in detail from the previous one described, the principle being that of the injector, though without any cone, there being no control of the proportion of the two gases that pass in by orifices, such as are shown at *A*, *B* and *F*, the size of the orifices in these tips being accurately determined for the various sizes of tips for the amount of gas required, thus insuring the correct proportion at all times.

At *K* is shown another type in which there are passages which regulate the amount of gases passing through, but these are in the head of the torch instead of the tip. Therefore when a larger or smaller tip is inserted, the mixing passage remains the same, so that only one of the set of tips for that torch has orifices correctly proportioned.

At *L* is a diagram representing the cutting operation. This torch tip has a central passage through which the jet of oxygen passes. It has a side passage which carries an ordinary heating flame, the cutting being in the direction of the arrow, so that flame heats the metal in advance. There is also a following flame which is just the same as that used for welding, merely for the effect of keeping the slag fluid so that it will run out of the weld.

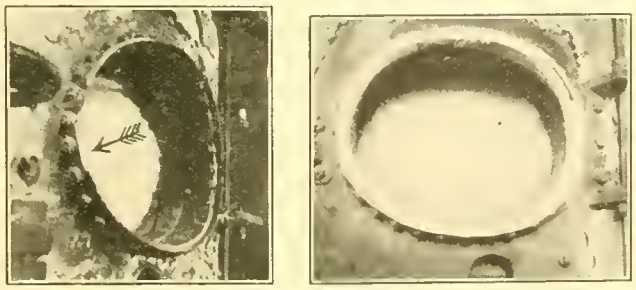


Fig. 4 An Example of a Corroded Firedoor Flange Built up with the Oxy-Acetylene Process

The process of oxy-acetylene welding and cutting is being used to a considerable extent for the repairing of steam boilers. In Fig. 3 is shown the welding of side plates in the firebox of a locomotive, the welds passing along each side and also patches being put in. It can be realized that having a row of rivets above the fire in a locomotive firebox is liable to cause trouble; by welding, this is entirely done away with. That weld has been in use on the Boston & Albany for three years, and proved perfectly satisfactory, as have others. In Fig. 4 is shown the building up of a corroded fire door flange. The corrosion is indicated by the arrow. In the ordinary way, it would be necessary to cut a large piece out and make a new flange and then put a row of rivets around both on the inside and the outside, and these rivets would have to be put in under very awkward conditions, owing to the small space, working through a hand hole, with the result that they might not be tight, whereas simply by building up as shown here, the work was made perfectly satisfactory.

There is, however, need of restrictions on boiler welding, because at the present time a welding equipment can be purchased at a very low figure, and unfortunately the concerns putting out the cheap equipments do not give instructions with their equipments, with the result that anyone purchasing an equipment can, without any knowledge of its operation, go ahead and carry out welding on a boiler. Sometime, and I guess it has already happened, destruction will result which will cause large restrictions in the use of this process. We are advocating that somebody, federal, state or other inspection authorities, make a law that no work shall be carried out on boilers unless the equipment has been tested to see that it will make a strong weld, and that it avoids the surplus oxygen which may pass through the flame oxidizing the metal and making a weak, brittle weld. The operator should be certified as to his ability to make a good, strong weld.

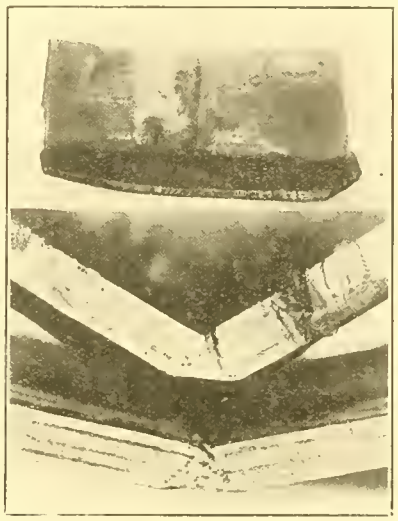


Fig. 5 Examples of Defective Welding by Improper Use of the Oxy-Acetylene Process

Even when these two conditions are perfectly obtained, success is not assured, because the operator is frequently merely an unskilled "handy man" who has been instructed in the knack of making a strong weld, but has no knowledge of boiler structures or the strength of metals or their heat treatment, and therefore is not capable of judging the conditions under

which welds should be made. We therefore claim that a third license should be given to the concerns that use the licensed operator and the licensed equipment, and until those three licenses are obtained welding should not be allowed on boilers. This does not imply that satisfactory work cannot be done on boilers at the present time, but as there are so many concerns who cannot do a satisfactory job of this sort, it is more by luck than good management when the right firm is chosen for the work.

Fig. 5 illustrates some of the possibilities of defective welding. Here is a weld that caused a disaster where there was considerable expense and loss. The weld is not thoroughly made. It was not made completely through and it is considerably oxidized. Regulations should be enforced so that it is not possible to get such a condition as that. Assuredly if the operators and concerns were licensed, they would not produce work of that nature. This process of welding is developing a number of other lines of metal working. For instance, pressed steel is coming into use very largely everywhere it is possible to use it, but its use has been limited to what could be made in dies. Pressed work in connection with welding has no limits, because the parts can be made in sections and then welded together. Fig. 6 shows the welding of such pressed parts, these plates being pressed up and welded together to make an expansion joint for steam piping. The parts are all welded together to make an accordion arrangement, the welding being around the inside and outside. It would not be possible to make that article without the oxy-acetylene welding process.

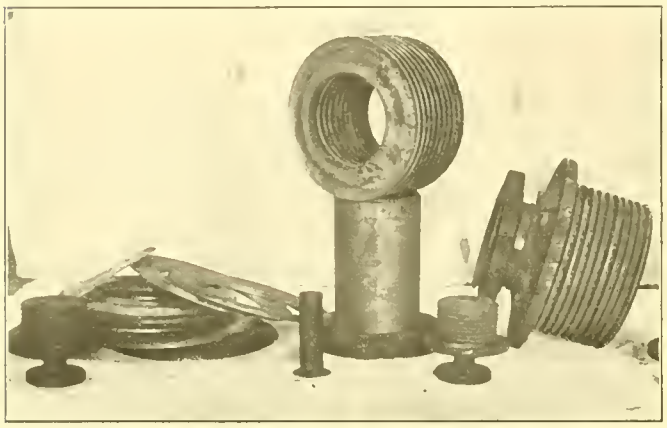


Fig. 6 An Example of Welding together of Pressed Steel Parts to Form af Expansion Joint

Cast iron can be welded perfectly satisfactorily. The metal will be soft if the work is carried out by a skilled operator with an equipment that does not remove the free carbon by combustion with the surplus oxygen in the flame, and it can be made so soft that expensive milling cutters and other tools can be used on it without any fear of their being damaged.

Fig. 7 shows a large flywheel, 20 ft. in diameter and weighing 24 tons, which was being moved from one mill to another and was dropped so that one spoke was broken out entirely and two spokes were cracked. It is easy to realize what an expense it would be to put in a new wheel, and also the time it would take. It was reported that the loss would have been $4800, but the wheel was welded up at a charge of $200 and put back into use. Thus a tremendous saving can be made, not only in the difference between the cost of welding and a new piece, but also the saving in time and use of the engine.

In making welds on a wheel of this size, it is not possible to turn it over and weld both sides, so the fractures were welded and reinforced by building up from the top side. There would naturally be some signs of the crack on the other side. It is well known when a piece of metal is nicked, it breaks very readily, and if a nick is left in the welding, it is much more liable to break than if it is welded up solid; so it was necessary to weld all around. The welding on the under side was carried out by the operator welding overhead. Cast iron, when it becomes liquid, is practically like water, and it was really a remarkable piece of work in welding up and building on that metal all the way round, part of it being done from underneath. The weld was tested with a sledge hammer to prove there was no internal strain in it. It was then run at calculated over speed, and I believe was reinsured by the insurance company that previously had carried the risk.

Fig. 7 An Unusual Case of Welding in Broken Spokes in a 20 Ft. Flywheel

Fig. 8 shows a weld in aluminum, which is an extremely difficult metal to weld, owing to several conditions. One is that it oxidizes so rapidly; another is that it has practically no strength when it is a few hundred degrees in temperature, being about as strong as a piece of potato. It has also high conductivity, so that a large portion of the piece is heated and the heat wasted. It has very high expansion and contraction. All these conditions make it an extremely difficult metal to handle; and yet it is possible to weld it as shown here.

What I believe to be the largest welding job that has ever been carried out and at the greatest saving, was carried out on the steel pipe line at Boulder Mountain in Colorado. The Colorado Power Company built this pipe line, using butt strap construction, which proved faulty. They tried all kinds of ways to correct the difficulty, but without avail. The trouble was that the water leaked out from between the butt straps, the water having a head of some 1700 ft., giving 825 lb. pressure at the base. The pipe was 4 ft. in diameter at the bottom and 1¾ in. thick. A tremendous amount of water came out from these joints and it was threatening to wash away the foundations and destroy the whole structure. Something had to be done immediately. Half a million dollars had been put into the structure and the whole thing was being held up. Finally it was welded by the oxy-acetylene process, in the winter on the side of the mountain, in a temporary structure which was moved from one point to another. A V-groove was first cut so as to make a deep weld, with the cutting torch. Part of the pipe ran through a tunnel, and joints were made at the mouth of one of the tunnels. The joints were all reinforced to 2½ in. thick, and gussets were also put in. The cost of that job, which was located some miles from any car line, was over $30,000, but it saved at least a quarter of a million dollars.

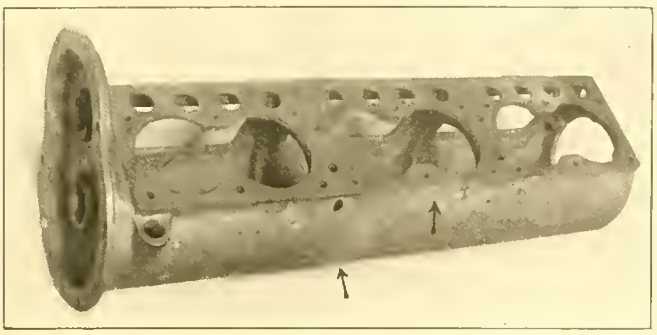


Fig. 8 An Example of Welding on an Aluminum Motor Crankcase

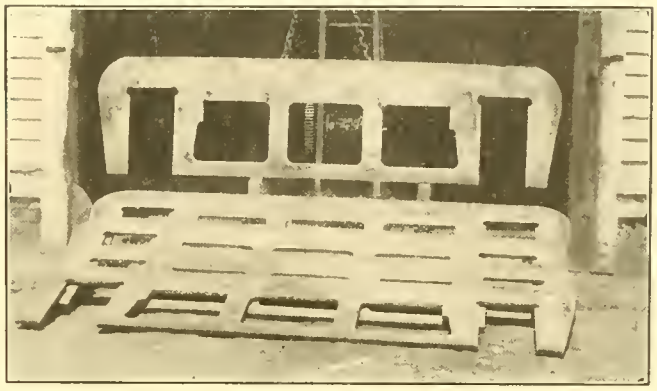


Fig. 9 A Motor Car Truck Side Frame Cut out of Steel Plate with the Cutting Machine

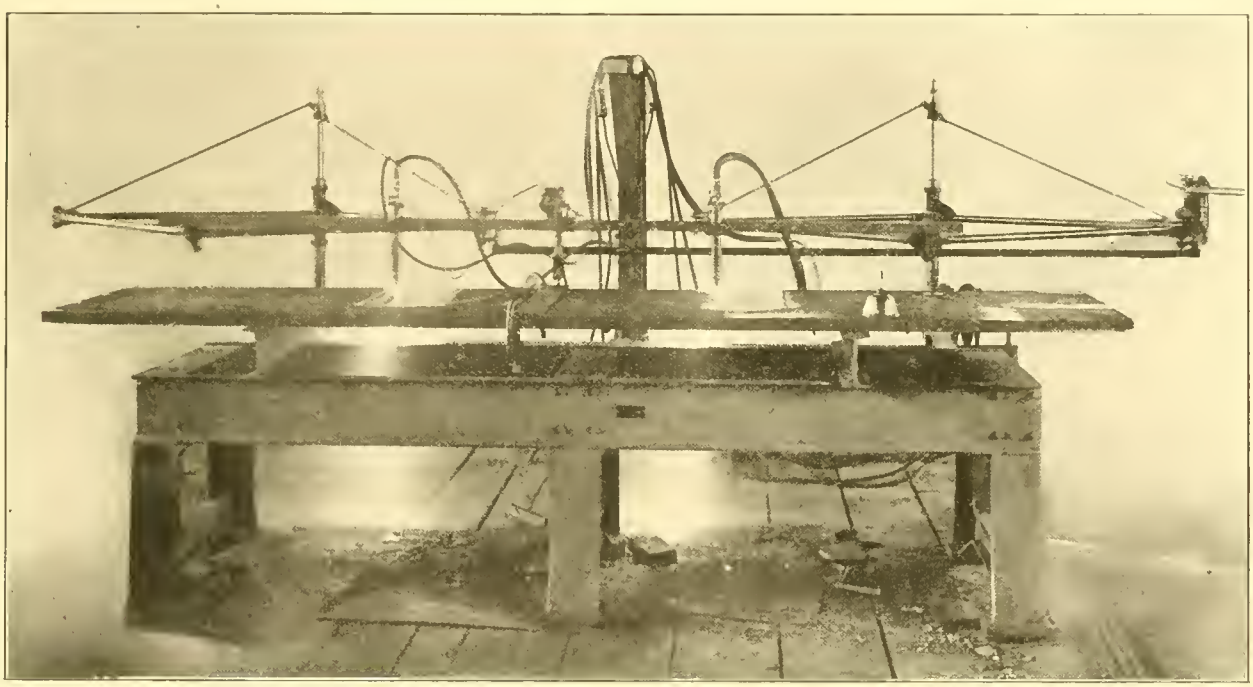


Fig. 10 View of the Oxy-Acetylene Cutting Machine in Operation with Two Torches forming a Steel Side Frame for an Electric Locomotive

In Figs. 9 and 10 is shown the method of cutting out frames for the trucks of motor cars. Previous to this process, the plates were cut by machine-shop methods, embracing first boring large holes, and then putting them on a planer and a shaper using parting tools. A row of holes is drilled for long curves, the metal broken off and an air chisel used to trim up. It took three days to get one out; whereas they are now cut out in 2 hours. They are ⅞ in. thick and about 12

feet in length, there being about 45 ft. of cutting. Each cut must be set separately, which takes most of the time.

The machine used for this work is shown in Fig. 10. It is a machine adapted for a variety of cutting operations of the kind usually handled on a vertical slotting machine or horizontal shaper, but it does the work much faster than a cutting tool. There is a substantial bed for holding heavy steel plates or forgings and an extension at the rear supports the pantagraph motion that guides the cutting torches. The double pantagraph frames are made of steel tubing and all joints provided with ball bearings. A horizontal bar is secured to the pantagraphs at the points opposite their pivots on the vertical supports. The tracing wheel which governs the movements of the torches is attached by a sliding block to any position on this bar according to the pattern or drawing to be followed and the required position of the torches. One or more torches are attached to the bar by similar sliding blocks. The illustration shows the tracing wheel at about the middle of the bar and a torch on each side making duplicate cuts. The tracing wheel is driven by a small electric motor which is provided with a centrifugal governor for regulating the speed at which the torches are moved thereby over the plate or material to be cut.

A full size drawing of the cut that is to be made is placed under the tracing wheel. The tracing wheel then follows the outline on the drawing and causes the torch or torches to follow a similar path over the work. The most irregular outlines can be easily followed. The speed at which the machine cuts is from 3 to 12 in. per minute, according to the thickness of the work. The torches used are the regular two-hose machine cutting torches manufactured by the Davis-Bournonville Co., vertical adjustment of the torches being obtained by means of a pinion operated by a thumb-screw which meshes with a rack cut in the body of the torch. The entire pantagraph motion can also be adjusted vertically by means of a handwheel at each end of the machine, which operates pinions meshing with rack teeth cut in the vertical supports. Any further adjustment that is necessary is then obtained by regulating the height of the torches with the thumbwheels. The latter adjustment permits, on certain classes of work where the thickness varies, of adjusting the height of the torch while cutting.

With this machine a cut may be made at any point over a surface 42 by 84 in. in size without shifting the torch on the bar. By shifting the torch or by using two torches, the area over which a cut can be made is increased to 42 by 168 in. Where duplicate work is being done or where two similar cuts are to be made in a single piece, the output of the machine is greatly increased by using two torches simultaneously. An example of this kind is shown in the accompanying illustration, Fig. 10, where a steel side frame for an electric locomotive is being cut.

THE THERMIT PROCESS OF WELDING

By W. R. Hulbert, New York

Member of the Society

Aluminum, which is the basis of the Thermit process, is the most widely distributed metallic element in the earth's crust, but it is an expensive metal as compared to iron and other more common metals because wherever it is found, it is always in combination with oxygen in one form or another, and it is only within comparatively recent years that any commercial process has been perfected which will separate aluminum from oxygen and enable the metal to be produced at a cost to make it generally available.

The fact that aluminum is hard to separate from oxygen is taken advantage of in the Thermit reaction as the high affinity of aluminum for oxygen permits of a chemical reaction between the two when they are heated hot enough. For many years since aluminum was discovered, chemists have known of this reaction and experimented with it in the reduction of different oxides, mixing finely divided aluminum with a metallic oxide, placing the mass in a crucible and then heating it until the reaction took place. It was found that this resulted in a very violent reaction, practically an explosion, so that the reaction was of no commercial value. Dr. Hans Goldschmidt, a German chemist and metallurgist, discovered that this reaction could be controlled, if instead of heating the entire mass, he simply heated the mass in the crucible at one spot. The reaction would then spread through the rest of the mixture and at the end of the reaction he would have aluminum oxide or slag floating on top in a molten state and the reduced metal at the bottom of the containing vessel.

This discovery was the result of experiments by Dr. Goldschmidt, who was attempting to produce for Krupps, the steel makers in Germany, pure metals to use as alloys with steel, and the first experiments were made with chromium oxide and finely divided aluminum. This reaction was entirely successful, as aluminum combined with the oxygen in the chromium oxide and pure chromium metal was reduced. He later experimented with other oxides, sulphides and chlorides and succeeded in producing pure manganese, ferro-chromium, molybdenum, ferro-titanium and many other metals and alloys.

In experimenting with iron oxide, it was found that this reaction not only produced a very pure, low carbon steel, but that the heat of this reaction was extremely high. No pyrometer will measure this temperature, but it has been worked out theoretically by Professor Richards of Lehigh University as approximately 4881 deg. fahr. Dr. Goldschmidt decided that this intense heat, produced so quickly and easily, could be used for welding purposes, and the Thermit welding process which is now widely known throughout the world is the result.

In making a Thermit weld, the parts to be united are first arranged with a space between them varying from ½ in. to 2 or 3 in., depending upon the size of the sections. In the case of a fracture, it is often necessary to cut out the metal in order to provide the space needed, and this is done by drilling a line of holes along the fracture and then cutting out the metal between the holes or else the space is cut out by means of the oxy-acetylene cutting flame. In the case of welding locomotive frames, which is the most important application of the process, it is almost always necessary to cut out the fracture.

After the sections have been cut out, a wax pattern is formed around them to the exact shape of the reinforcement of Thermit steel which is to be cast around them to make the weld. The wax pattern is enclosed in a sand mold, wooden patterns being used to form a pouring gate, also a small preheating opening at the bottom and a large riser directly over the top of the weld. In order to remove the pattern it is only necessary to apply the flame of a compressed air gasolene preheater into the preheating opening and the wax is melted out, leaving the mold ready for pouring. For that part of the mold which comes in contact with the Thermit steel a mixture of one-third fire clay, one-third ground firebrick and one-third good sharp silica sand is used; this is mixed dry and then moistened just enough to tamp well. This is used only for the facing material and is backed up with a mixture of one-third fire clay and two-thirds sand. This mixture is recommended because it is highly refractory and the Thermit steel goes into the mold at such a high temperature that a very refractory facing is necessary. The mold is, of course, thoroughly vented in accordance with good foundry practice.

After the wax is melted out by the preheater, the heating is continued until the parts to be welded have been brought to a good red workable heat. In the meantime, the charge of Thermit is placed in a conical shaped crucible suspended over the pouring gate of the mold, and when the sections are red hot, the preheater is withdrawn, the preheater opening plugged up and the Thermit charge in the crucible ignited. In from 40 to 50 seconds the Thermit reaction is completed and the Thermit steel tapped from the bottom of the crucible into the mold where it flows around and between the sections to be welded together, uniting them into one solid mass. The slag (aluminum oxide) does not enter the mold, but overflows at the pouring gate so that it does not interfere with the welding operation.

The process is a simple one and the only outside power required to weld sections of any size is a small supply of compressed air for the operation of the preheater. The outfit is portable and in many cases sections of very large size are welded without removal from their position, and therefore at a great saving in time and expense over obtaining new parts. This is particularly advantageous in the case of broken locomotive frames. It saves taking the frame out of the engine, welding it in a forge and replacing it. Furthermore the process permits of fusing a collar or reinforcement of steel all around the welded part, thus increasing the cross-section at that point and making it stronger than it was originally.

In welding a locomotive frame it is necessary to jack the frame apart from ⅛ to $\frac{3}{16}$ in. before putting on the mold in order to allow for the contraction of the Thermit steel when the metal in the weld cools. Where one part of a double-bar frame is being welded this contraction is allowed for by heating up the other section so as to expand it the required amount and holding that heat until the metal in the weld has solidified, after which the heat can be taken off and then both

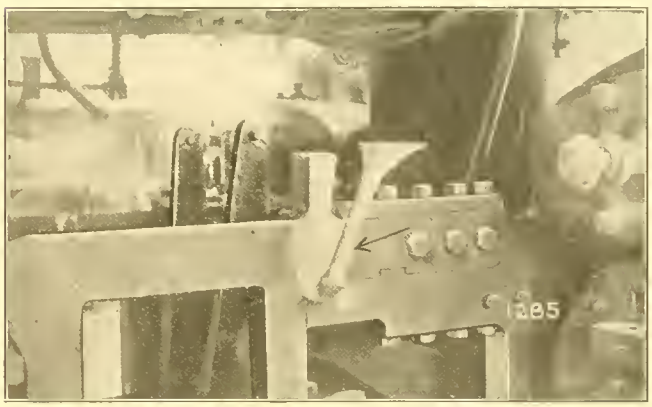


Fig. 1 A Completed Thermit Weld on a Locomotive Frame, showing Pouring Gate and Riser

sections will cool down and contract together. For such work a double burner preheater is used; one burner to preheat the sections to be welded while the other is directed into a small brick furnace erected around the second member in order to obtain the desired amount of expansion. A completed weld on a locomotive frame is shown in Fig. 1 with the mold removed.

The great economy of the process in locomotive repair work has led to its adoption by practically all the railroads of consequence in the United States, Canada and Mexico, and it is interesting to know that the process is now used in 421 different railroad shops in North America. Very little stripping of the engine is required for a Thermit weld, as it is necessary to provide only a clearance of about 1 ft. all around the broken section. In fact it is usually only necessary to drop the driving wheels in order to effect a repair on a broken frame. Often the engine comes into the shop in the morning and 12 hours later the frame will be welded and the locomotive ready for service. Thermit is also applied to equal advantage in the welding

of broken driving wheel spokes, side rods, connecting rods, rocker shafts, cross head guides, cylinder saddles, mud rings and other broken sections too numerous to mention.

The Thermit process is used extensively in the marine field for welding broken stern posts, stern frames, rudder frames and propeller struts of steamships. Here the process results in even greater economies than in the case of locomotive repairs owing to the fact that drydockage is exceedingly costly and every day saved means hundreds of dollars. Such repairs seldom keep the vessel in drydock more than 48 hours. The United States Navy has used the process very extensively at

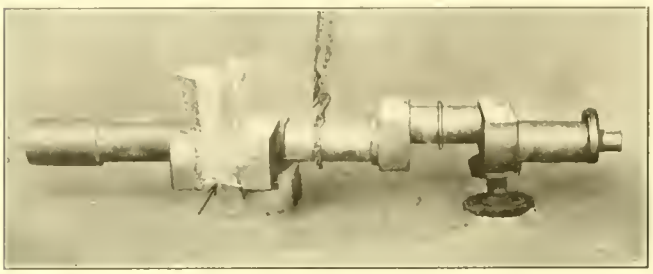


Fig. 2 A Completed Thermit Weld on a Large Refrigerating Machine Crankshaft

the Boston, New York, Norfolk, Portsmouth and Charleston navy yards, and the repair ships Panther, Dixie and Vestal are completely equipped with Thermit welding outfits and have done very important work.

A great many crankshafts have been welded by this process, particularly shafts for refrigerating machines. These shafts have to be aligned quite accurately before making the weld, and it is found best to mount them on V-blocks supported on a machined bed plate. In some cases it is found necessary to cut out an entire bearing and weld in a block of steel to replace it with two Thermit welds, one at each end, the shaft being then placed in a lathe and the bearing turned down to the proper size. It is usually impossible to keep these shafts in exact alignment during the welding operation, but they are seldom out more than $\frac{1}{32}$ in. This is readily corrected by taking a light cut off the bearings between the weld and one end of the shaft, considering the other part of the shaft to be true. In Figs. 2 and 3, an example is shown of a Thermit weld on a large crank shaft.

While a great many of these shafts have been welded with Thermit, we have never had one break at the weld, and our theory is that the shafts almost always break because of some flaw or defect in the material. This is often an old forging crack in the case of built up crankshafts, which gradually spreads until finally the shaft gives way. Of course, a shaft with such a flaw has no factor of safety at all, but if it were properly constructed it should have a factor of safety of five. After the weld is made and all surplus metal machined off the shaft will still have a factor of safety of at least four, which is ample for all purposes and the owner will really have a better shaft than originally because the flaw has been located and eliminated and the rest of the shaft has, of course, been thoroughly tested.

This process has also been used for large welds on gear wheels, flywheels, hoisting engine shafts, rolls, pinions and roll mill housings. In the case of broken rolls and pinions, it is usually necessary to cast on entire new ends and as this would prove rather costly with Thermit steel, we have devised a method which is just as effective and considerably less expensive. This method is now generally used by practically all the large steel mills in the Pittsburgh district. The broken roll or pinion is placed vertically in a pit and a mold constructed around the fractured end. This end is then heated to a red heat by means of gasolene preheaters, after which it is covered with Thermit steel to bring it up to a fusing temperature. Liquid steel from a ladle is then poured into the mold and about 6000 lb. allowed to run through and overflow. The overflow gate is then plugged up and the mold filled to the top. When the metal in the mold cools it will be found to have welded perfectly to the steel of

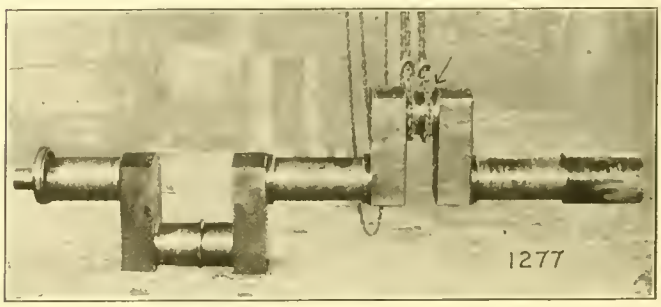


Fig. 3 View of the same Crankshaft after Welded Crank pin was Machined

the roll. The hot metal passing through the overflow gate is not wasted, but is caught in ingot molds and used in the regular way.

Another important application of Thermit is in pipe welding. The method of doing this work is novel and simple. Advantage is taken of the temperature of the slag and the fact that this slag will not stick to the pipe. On this account the mold for the purpose can be made of iron and surrounds the pipe ends which are accurately butted together and held in place with clamps. The Thermit is ignited in a flat bottom crucible and at the end of the reaction the slag which floats on top of the Thermit steel is poured into the mold, the steel going in afterwards. The slag and steel combined serve to bring the pipe ends up to a welding temperature, at which time they are squeezed together by means of the clamps and a butt-weld effected. At

the end of the operation the entire mass may be knocked away from the pipe and the only resulting effect will be a slight upset in the surface of the metal at the joint.

This type of welded joint is used extensively in refrigerating plants, particularly where ammonia pipe lines are used and where a permanent non-leakable joint is desired. The Thermit process not only eliminates all joints from the pipe, but the welded joints are actually cheaper to install than ammonia flanged connections. For instance, the cost, including labor, of welding a 1-in. standard pipe by the Thermit process, is about 65 cents, while ammonia fittings will cost at least 75 cents. Another advantage is the speed with which the welds can be made, as two men can easily make from 40 to 50 pipe welds per day. One man will face up the ends of the pipe with a special pipe facing machine, while the other follows and does the welding. As no outside power is required the welds can be made anywhere and the operation is just as economical in the field as in the shop.

In rail welding, the Thermit process offers a field of usefulness to street railway companies, as the apparatus is simple and enables a few joints to be welded almost as cheaply as a large number. The life of the rail depends very greatly on the efficiency of the joint as it always wears out and batters where the joints occur. Welding not only prolongs the life of the rail but also reduces the resistance of the return electric circuit. In making a rail weld, Thermit steel is fused around the base and flange of the rail and also around both sides of the head. The head is, however, not welded entirely with Thermit steel, but an insert of rail steel is placed between the two rail ends and this is heated to a welding heat by the Thermit steel and slag, and later when the weld begins to cool and contract, it is compressed between the rail heads and butt-welds to them. In this way a weld of the entire rail section is obtained, but one which does not in any way affect the wearing quality of the metal in the head of the rail which has to withstand traffic. After this joint has been welded it is ground to proper form by means of a special rail grinder which has been perfected for that purpose.

In addition to the above applications of the process it may be stated that Thermit is used quite extensively in foundries and steel works for reviving dull iron in the ladle and keeping risers of castings liquid. For that purpose the Thermit is supplied in cans which may be attached to a long rod and plunged into the ladle of iron or held in the riser. The Thermit there reacts and heats up the iron or steel in which it may be immersed. The reaction of the Thermit charge in the molten metal sets the iron free as highly superheated steel at a temperature of nearly 5000 deg. fahr., or about twice the temperature of ordinary molten steel, which is very effective for this purpose.

ELECTRIC WELDING

By W. A. Hodges,[1] Lynn, Mass.

Non-Member

The electric resistance process of welding and heating, sometimes called the incandescent process as distinguished from the electric arc process, consists in causing a heavy current of electricity to pass across the joint at the lowest voltage which will drive the current through the pieces to be welded, to bring the metal at the junction up to a welding heat, and at the same time pressing the pieces together to make a complete union or weld. The pieces to be welded together when clamped in a welding machine complete an electrical circuit but are inadequate to carry the heavy current passing through them without heating: as the heat increases the resistance also increases and the union or weld is thereby accelerated, but the volume of current is decreased, or in other words, as the temperature increases, the current volume usually decreases, a greater volume of current being used at the beginning than at the end of the heat effect. The heat is confined to the metal between the jaws and a welding heat is reached so quickly that there is very little time for waste through radiation or conduction by adjacent cold metal; therefore practically all the heat is consumed in useful work, and the pieces not having been heated except at the joint, are not distorted or even discolored.

The electric resistance process of welding and heating is distinguished from all other processes by the fact that the heat is generated in the metal itself, uniformly over the section, while by all other processes the contrary is true; the heat is applied to the exterior and is conducted into the interior. Absolute control of the heat is obtained; the pieces are heating in full view of the operator and, if, due to uneven contact of the pieces, rust or scale at one or more points of contact or other irregularity, the pieces heat unevenly with a tendency to burn at one or more points, the heating effect can be instantly stopped until radiation restores the heat equilibrium, when the heating can instantly be resumed and all danger of flaws avoided. Various degrees of temperature can be obtained and retained for any length of time. Usually no flux is required.

This process is employed principally in the following classes of welding operations:

- Butt Welding, end to end: whole abutting surfaces, of nearly same cross-section, welded together
- Tee and Angle Welding, in the form of a letter T or L
- Cross Welding, in the form of an X
- Lap Welding, overlapping and squeezing or mashing together
- Seam Welding, either by abutting, or overlapping, the edges of sheet metal

[1] Treasurer, Thomson Electric Welding Co.

Spot Welding, instead of riveting; practically one spot at a time

Point Welding, surfaces in contact only at a raised point or multiplicity of points, at which the current is confined; welding only at these points. Usually in sheet metal

Ridge Welding, instead of a point, a ridge, across which a weld is made

Upsetting, to form collars and the like, and

Heating, of blanks for forging, bending and working.

The process is especially well adapted to duplicate work where as large an output as possible per operator is required and the wagon, carriage, automobile and bicycle industries, with tools, wire, pipe, tubing and a large line of miscellaneous and special work provide the field for the process. It is particularly applicable to new work rather than to repairs, although some repair work is done in iron and steel, but the process is not applicable for the repair of broken or defective castings unless of such metals as brass of simple forms. Practically all metals can be welded, also all sorts of steel and many alloys, as well as many combinations like carbon steel to mild steel, nickel and brass to platinum, cast steel to machine steel, malleable iron to steel and a great variety of other combinations. In the last few years there has been a great development in the manufacture of sheet metal articles and the electric spot weld has been found a much cheaper and better method than riveting, especially with the lighter gages of sheet.

Rust is an insulator for low voltage and should be removed at those parts of the pieces which come in contact with the electrodes. In butt welding the two pieces, if of the same metal, should have practically the same cross-section at the joint, and when a larger piece is to be welded to a smaller, the end of the larger piece should be reduced to the section of the smaller for a length depending on the section or diameter. The upsetting of the ends together to make a butt weld causes the joint to be enlarged, according to the character of the metal and the kind of weld required, by a burr, fin or swelling; if objectionable, this can be removed under a press or hammer while the metal is hot, or in thin flat stock, where there is not enough heat to work, the light fin can be ground off.

The electric current transformer, the clamping device and the pressure device are the three necessary elements in an electric welding machine. Although it is possible to give the transformer a different location from that of the two mechanical elements, it is rarely done, the commercial welding machine employing all three elements in the same structure. There are, of course, many special departures from this general form. The mechanical and electrical controls may be operated by hand, by foot, or may be automatic and operated by power. For small work like welding wire, spring pressure in forming the weld is usually employed, and clamping either by hand or by power; for metals like copper and brass a weight pressure is usually best; for rounds and like sections up to ¾ in. hand pressures are usually employed; in larger sections, hydraulic pressure or pressure obtained through self-contained oil jacks is used.

Electric welding machines are necessarily more or less special in the construction of their clamps and electrodes, no one machine being suitable for a great variety of sizes or forms of work, and some are entirely special and suitable only for the work for which they are built. Some are called semi-automatic, as when the operator's duty is only the putting in and taking out the pieces, while other machines are entirely automatic, clamping, exerting pressure for welding and controlling current.

Power machines for spot welding are being built with heating time adjustments and regulation so that the machines can be set for the right speed and the correct time of heating required for varying thicknesses and conditions of stock. They can be operated continuously or intermittently as necessary, so that the greatest amount of work which the operator can handle will be taken care of by the machine.

There is no process by which the heat can be delivered to metal so quickly as by the electric resistance method. In small wire a fraction of a second only is required for welding, while with larger pieces proportionately more time is required. Welds can be made either quickly or slowly, depending upon the amount of power available. It is always desirable to have ample power so as to make the weld in the quickest possible time, as better results are usually obtained, and time and power are saved. A ¾-in. round can be welded with 15 kw. in 15 seconds or with 23 kw. in 6 seconds. Endless pieces like rings take more power, as the diameter decreases; copper and brass, more power and less time than steel or iron of like section.

The expense for current is small, as it is used only while the pieces are heating in the welding machine, which is from one-quarter to perhaps one-half of the time of the day's run. The welding machine is always ready if the current is available by simply closing a switch, and when the weld is made the expense of consumption of energy instantly stops. The output per day for any welder depends, of course, upon the size of the stock to be welded, the shape of the pieces, and the facilities for handling. In wire hoops, under the best conditions, 1000 welds can be made per hour, while in very heavy tires, 100 per hour would be a very good output.

Large volumes of current at low pressures are required, approximately from 2000 to 50,000 amperes, at from 1 to 7 volts, being used for welding from ¼ in. to 3 in. round or equivalent section. The pieces to be welded when mounted on the terminals of the transformer, complete an electric circuit, all parts of which, except the pieces to be welded, are adequate to carry

this heavy current without heating excessively or without much loss of energy. The current depends on the section of the pieces and the speed of welding.

An alternating current wired from a single phase, or from one phase of a multi-phase system is the most convenient and is universally used. A current of any usual frequency can be employed, the welding transformer being adapted for the conditions, 60 cycles usually being found, although welding machines are employed on circuits of 25 cycles and even as low as 11½ and 15 cycles. The pressure also may be any commercial voltage, 220 volts being commonly available, although welding machines are operated on circuits ranging from 104 volts to 550 volts.

This current is usually obtained from the local lighting and power company rather than from individual generating plants, although in cases of large electric welding installations individual generator equipments are used. In installations of single welding machines, the current being used intermittently, the actual kilowatt-hours consumed in a day's run are small and the expense of current so light that an individual generator is not desirable.

The welder being a machine with self induction, the power factor is low, sometimes 50 per cent, varying according to conditions, but rarely higher than 70 per cent. The nature of the load on the generator supplying the current is different from that of almost any other current consumer except some forms of alternating-current motors on account of the fact that when the circuit is closed through the breakswitch, the full amount of power required to make the weld is instantly thrown on the generator; and instead of building up from a minimum to a maximum, the maximum is first demanded of the generator. This necessarily creates some disturbance on the line.

When the visible surface of a piece (outside) reaches a welding heat the interior is necessarily also at a welding heat; for this reason, a more uniform result and a greater percentage of good welds can be obtained, and at least as strong, if not a stronger weld can be made than by any other method.

No table of strength of welds is presented, but in general it may be said that in good open-hearth mild steel, almost, and in some cases, quite the strength of the metal section is obtained. Bessemer steel, being frequently higher in sulphur and phosphorus, cannot always be welded with such good results.

In high carbon steel the heat is so distinctly localized and its dissipation is so fast when the current is withdrawn, that just at either side of the weld the metal is chilled and may be more or less brittle. To overcome this, it is the practice to reclamp with the electrodes wider apart, letting the current flow through the brittle parts until they come to an annealing temperature. Reheating may be repeated when needed.

A spot weld frequently is much stronger than a rivet. In very thin sheets the metal pulls away leaving a hole in one sheet with the metal of the weld adhered to the other sheet.

Fig. 1 shows in the left upper corner a steel pinion and a composition base piece with a boss to which the pinion is welded. The welded piece is also shown with the upset, represented by a fin around the joint. The three middle pieces are interesting specimens, showing the possibility of simplifying forgings by making them in two parts and then welding them. The first two pieces represent the two parts and the third piece at the right the completed piece, showing the weld. At the right-hand corner is a miter joint in a 1 in. pipe. This is rather an unusual weld. The two lower pieces are interesting examples of building up a structure from different parts. The two end pieces are forgings,

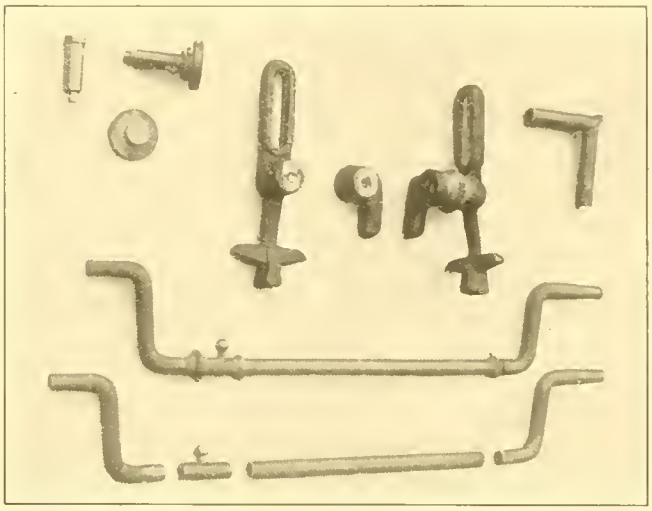


Fig. 1 Examples of Recent Applications of Electric Welding to Manufacturing Processes

also the small middle piece. The other middle piece is tubing. Three welds are made in the piece, which is shown welded above. The ends of the forgings to which the tubing is welded are milled out to give them a section like that of the tube.

There is an infinite variety of welding work which can be done by the electric resistance process, an interesting example of which is the welding of rails for the street railways, taking the direct current from the overhead trolley, transforming it to alternating current and welding plates across the joint, making a practically continuous rail. This work is being very extensively done in the large cities. An unusual method of making agricultural wheels consists in assembling the spokes in two halves of the hub and mashing them all together at one operation in a welding machine. There should also be mentioned the welding of wire fabric used in wire fencing and for concrete reinforcing, for which has been developed the only fully automatic electric welding machine; the strand wires and the stay wire are fed into the machine and welded automatically at all intersections.

MEETINGS OF THE SOCIETY IN CHICAGO

THE January and March meetings of the Society held in Chicago are of interest because of their bearing upon steam power plant topics: At the meeting of January 28, 1914, Bryant Bannister of Pittsburgh, Pa., read a paper on Tests of Four-Pass Boilers with Illinois Coal. On March 18, a banquet was held at which four prominent power plant engineers talked on the topic of Large Steam Power Plants, discussing the various phases of present-day operation and suggesting improvements for the future; the speakers were as follows: I. E. Moultrop, of the Edison Electric Illuminating Company, Boston, Mass.; J. W. Parker, of the Edison Illuminating Company, Detroit, Mich.; John Hunter, of the Union Electric Light & Power Company, St. Louis, Mo.; and W. L. Abbott, of the Commonwealth Edison Company, Chicago, Ill., all of whom are Members of the Society. The meetings and the discussion are reported herewith in abstract form.

TESTS OF FOUR-PASS BOILERS WITH ILLINOIS COAL

By Bryant Bannister,[1] Pittsburgh, Pa.
Non-Member

In April 1913 a new boiler house was completed at the works of the National Tube Company, at Kewanee, Ill. Because of some unique features of the installation, together with the fact that a low-grade Illinois coal was burned in the form of 1¼ in. screenings with very high efficiency, it was thought that the results of tests which were conducted would be of value to the engineering world.

A series of 11 tests of from 4 to 24 hours' duration, with loads varying from 75.6 per cent to 205.2 per cent of rating, was run primarily for the purpose of proving contract guarantees. However, with a Taylor stoker with which this plant was equipped, and its thick fuel bed, it is very difficult to estimate accurately the amount of either coal or ash on the grate, and the error which might occur in a test of short duration would be of considerable importance.

In order to eliminate, as far as possible, any error arising from this source, it was thought best to conduct a later test of much longer duration, so that any error in estimating coal on the grates at the beginning of the test would be spread over a sufficient period to make it comparatively insignificant. This test was run as a 72-hour test, completed October 30, 1913, some six months after the first 11 tests were made. The results of this 72-hour test are given in this abstract.

The complete boiler plant consists of four Edge Moor watertube boilers, each set as a unit, having 20-ft. tubes, and baffles arranged to give four passes for the gases, with the stack outlet at the bottom of the fourth pass. Each boiler has 6132 sq. ft. of water heating surface, Foster superheaters being installed. The boiler is set with the bottom of the front header 8.67 ft. above the level of the dumping plate of the stoker, thus giving the large combustion chamber so essential to the thorough combustion of highly volatile coals. The other furnace dimensions are 12.75 ft. wide by 8.50 ft. deep. The firing is done by a seven-retort Taylor stoker equipped with an air extension grate. Each stoker has its own fan and engine.

The feedwater is supplied from a purifying plant and is heated by the exhaust from the auxiliary engines in an open heater. Two turbine-driven centrifugal pumps, each having a capacity sufficient for the maximum steam generation, are so piped that any one of the four boilers may be supplied with feedwater by one pump, while the other pump supplies the water to the weighing tanks and to the remaining boiler units. Permanent water weighing equipment has been installed, consisting of two scale tanks of 2750 lb. capacity, and one supply tank of 4500 lb. capacity.

Much was done to make each boiler setting tight and as free from radiation losses as possible. The setting was first painted with a thick asbestos paint, and then covered with 1½ in. coating of 85 per cent magnesia heat insulator, and finally covered with muslin and again painted to insure no air leakage. The boiler headers were also covered, where exposed, with this same magnesia compound, and the whole setting top covered with a 3-in. layer of fire brick and cement, and then with magnesia covering. At no point during the tests was the setting more than warm, even at the highest loads.

During the tests the coal was dropped from a chute into a scale-box of 1000 lb. capacity and carefully weighed, then shovelled into the stoker hopper. From each weighing, a sample shovelful was taken and the aggregate of these kept in a tight metal box for each 8-hour run, and then quartered for a sample. Moisture determinations on coal were made by the National Tube Company, according to standard laboratory methods, and proximate analyses were made by both the National Tube Company and the Robert W. Hunt & Company from the samples obtained from the aggregate of the 8-hour samples. In test No. 12 it was found that the analysis made by the National Tube Company was

[1] Engineer, National Tube Company.

Abstract of Paper. Presented at the Chicago local meeting of The American Society of Mechanical Engineers on January 28, 1914. The complete report may be consulted in the rooms of the Society, 29 West 39th St., New York.

sustained by the heat balance and was accordingly used. (In test No. 12 the calorific value of 1 lb. of dry coal was found by the National Tube Company to be 11,094 B.t.u., and by the Robert W. Hunt and Company 11,026 B.t.u.) Ash analyses were made by the National Tube Company on samples from all tests obtained by the same method described above for obtaining coal samples, with checks by the Robert W. Hunt & Company on several tests. Care was taken in securing these samples of ash to obtain as nearly as possible the same proportions of fine ash and clinker as contained in the ashes dumped.

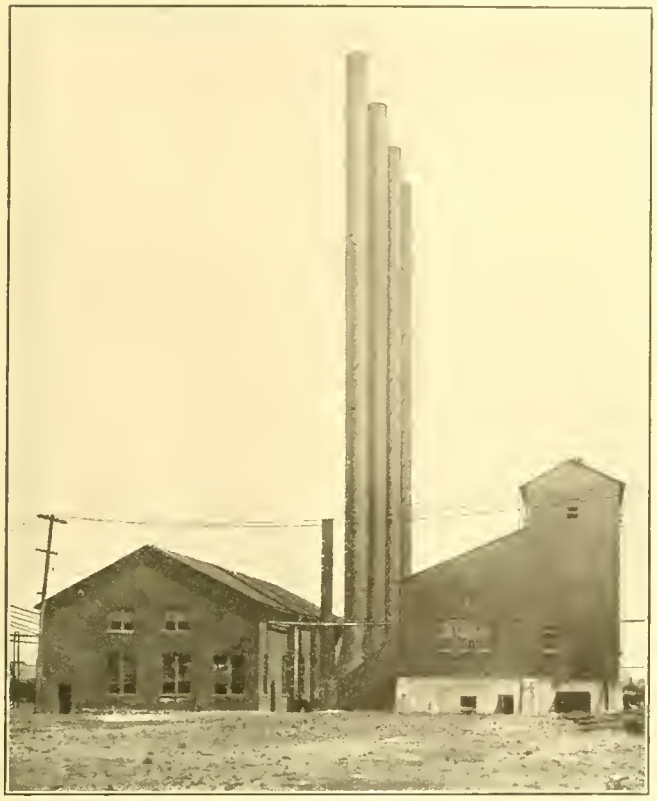


Fig. 1 Exterior of the New Boiler House at Kewanee

Flue gas temperatures were taken with duplicate thermo-couple pyrometers placed at the bottom of the last pass. Previous to tests these pyrometers were compared with a standard thermometer throughout the working range, and during the tests the average difference in the readings for the two instruments was about 6 deg. fahr.

Gland leakage on the test feed pump was weighed and accounted for, and no blowdowns were made during any tests. Safety valves on the test boiler were set several pounds above those on the remaining boiler units, but on the higher evaporations pop-offs were unavoidable, these being carefully timed and accounted for.

Flue gases were drawn from the bottom of the fourth pass and analyzed by an Orsat apparatus every 15 minutes, and check analyses were made occasionally with a second Orsat. All temperature and pressure readings were made every 15 minutes and the condition of the fire maintained in accordance with the gas analyses. Since each boiler unit has its own stack it was further possible to regulate properly the air supply to the stoker by observing the smoke condition. As shown by the data, the furnace draft was maintained as low as possible.

TABLE 1 DATA AND RESULTS OF EVAPORATIVE TEST NO. 12

Conducted by the National Tube Company, Kewanee Works, October 27-30, 1913, with Taylor Stoker of 91 Sq. Ft. Grate Surface, and Edge Moor Water-Tube, Four-Pass Boiler, of 6132 Sq. Ft. Water Heating Surface and 1200 Sq. Ft. Superheating Surface. Illinois Bituminous Screenings used.

Duration, hours	72
Average Pressures and Temperatures	
Steam pressure by gage, lb.	117.6
Temperature of feedwater entering boiler, deg.	194.9
Temperature of escaping gases leaving boiler, deg.	412.0
Draft in furnace, in.	0.011
Blast Pressure under Grate, in.	1.95
Superheat of steam, deg.	77.9
Total Quantities	
Weight of coal as fired, lb.	222,703
Moisture in coal, per cent	16.15
Total weight of dry coal consumed, lb.	186,736
Total ash and refuse, lb.	39,185
Ash and refuse in dry coal, per cent	20.98
Total weight of water fed to boiler, lb.	1,563,910
Total weight of water evaporated, corrected for moisture in steam, lb.	1,563,910
Total equivalent evaporation from and at 212 deg. fahr., lb.	1,727,964
Hourly Quantities and Rates	
Dry coal consumed per hour, lb.	2594
Dry coal consumed per sq. ft. of grate surface per hour, lb.	28.5
Water evaporated per hour, lb.	21,721
Equivalent evaporation per hour from and at 212 deg. fahr., lb.	24,000
Equivalent evaporation per hour from and at 212 deg. fahr. per sq. ft. of water heating surface, lb.	3.28
Capacity	
Evaporation per hour from and at 212 deg. fahr., lb.	24,000
Boiler horsepower developed	695.6
Rated capacity in evaporation from and at 212 deg. fahr., lb.	21,155
Rated boiler horsepower	613.2
Rated capacity developed, per cent	113.4
Economy Results	
Water fed per lb. of coal fired, lb.	7.022
Water evaporated per lb. of dry coal, lb.	8.375
Equivalent evaporation per lb. of dry coal, lb.	9.254
Equivalent evaporation per lb. of combustible burned	11.711
Efficiency	
Calorific value of 1 lb. of dry coal, calories	11,094
Calorific value of 1 lb. of combustible	13,773
Efficiency of boiler furnace and grate, per cent	80.95

TABLE 2 TEST AND COMPUTED RESULTS

Actual load, h.p.	696
Actual rating per cent	113
Engine speed, r.p.m.	225
Blast pressure, in. of water	1.95
Draft, in. of water	
Furnace	0.011
Fourth pass	0.255
Stack	0.90
Temperature flue gases, deg. fahr.	412
Superheat, deg. fahr.	77.9
Pressure gage, lb. per sq. in.	117.6
Feedwater temperature, deg. fahr.	194.9
Factor of evaporation	1.1049
Flue gases, per cent.	
CO_2	13.33
O_2	5.35
CO	0.08
Total	18.76
Coal	
Ash (dry), per cent	19.45
Hydrogen (dry), per cent	4.58
B.t.u. (dry)	11,094
Moisture, per cent	16.15
Carbon in dry ash and refuse, per cent	6.73
Equivalent evaporation per lb. of coal	
As fired, lb.	7.76
Dry, lb.	9.25
Equivalent evaporation per 10,000 B.t.u. fired	8.34
Equivalent evaporation per hr. per sq. ft.	
Grate surface, lb.	264
Heating surface, lb.	3.28
Coal per boiler horsepower-hour	
As fired, lb.	4.45
Dry, lb.	3.73
Coal consumed per hour per	
Sq. ft. grate surface, dry, lb.	28.5
Retort	
As fired, lb.	442
Dry, lb.	371
Lb. air per lb. dry coal fired	10.88
Efficiency boiler, furnace and grate, per cent	80.95

ANALYSIS OF FULTON COUNTY COAL

Proximate analysis of coal	
Moisture	16.15
Ash in dry coal	19.45
B.t.u. per lb. dry coal	11,094
Ultimate analysis of dry coal	
Carbon	59.15
Hydrogen	4.58
Sulphur	3.36
Ash	19.45

TABLE 3 HEAT BALANCE, EVAPORATIVE TEST NO. 12

	B.t.u.	Per cent	Per cent Correction
(95) Heat absorbed by boiler	8980	80.95	
Net correction to balance correction on items (96)–(102)			−0.79
Corrected efficiency		(80.16)	
(96) Loss due to evaporation of moisture in coal	231	2.08	
Same, calculated on average moisture in coal	(194)		
Correction to average moisture			−0.33
(97) Loss due to heat carried away by steam formed by burning of hydrogen	494	4.45	
Correction for items (96)–(97) on basis of corrected stack temperature			−0.03
(98) Loss due to heat carried away in dry flue gases	855	7.71	
Correction for item (98) on basis of corrected stack temperature			−0.21
(99) Loss due to carbon monoxide	35	0.31	
Same, average for all tests	(24)		
Correction to average carbon monoxide			−0.10
(100) Loss due to combustible in ash and refuse	223	2.01	
Same, average for all tests	(388)		
Correction to average loss of combustible in ash			1.49
(101)–(102) Loss due to radiation and unaccounted for	276	2.49	
Correction			−0.03
(103) Calorific Value of 1 lb. of dry coal	11094		
Total		100.00	0.00

NOTE—The above factors of correction were derived with items (indicated by numbers in brackets) of the complete code of the Society for boiler testing.

DISCUSSION

G. A. GOODENOUGH[1] commended the accuracy of the test instruments and measuring apparatus employed and stated that under the supervision of A. P. Kratz all instruments and apparatus were tested with special care and therefore the data set forth in the report of the test might be accepted as well within the limits of reasonable accuracy.

JOSEPH HARRINGTON (written). The heat balance has been worked out on a basis of dry coal, and the losses due to moisture and hydrogen in the coal and the heat in the dry flue gas have not been divided to show what proportion of each is a necessary loss. To this extent the analysis of the results is incomplete.

A perfect furnace would completely burn all the combustible in the coal fired, with just the theoretical amount of air. With no losses due to combustible in the ash, to CO in the furnace gases or to excess air, the furnace efficiency would be 100 per cent. A perfect boiler would cool the gases to the temperature corresponding to the pressure and would allow no infiltration of air or radiation of heat. The boiler efficiency would then be 100 per cent.

A perfect furnace and a perfect boiler would not, however, give 100 per cent combined efficiency, because nature imposes certain restrictions upon the process of burning coal for the generation of steam:

a Because coal is not a perfect fuel. With a perfect furnace and boiler the moisture and burned hydrogen in the coal will go up the chimney as superheated steam at the temperature to which a perfect boiler could cool the gases, but this temperature is higher than that of the atmosphere and a definite, necessary loss occurs.

b Because the gases must escape at a temperature at least equal to the steam temperature, which is, of course, always higher than the surrounding air. The theoretical amount of dry gases also carries away heat, which even a perfect boiler could not absorb.

The magnitude of these necessary losses depends upon the amount of moisture and hydrogen in the fuel, the boiler pressure, and the temperature of the air in the boiler room,

[1] Professor of Thermodynamics, University of Illinois, Urbana.

and until they are known and a proper allowance for their effect made, a test cannot be scientifically analyzed or two tests compared. For instance, a test of 78 per cent combined efficiency may be a better performance of both boiler and furnace than another at 80 per cent under different conditions, because the necessary losses might be more than enough to account for this difference.

After deducting the necessary losses per pound of coal as fired from the B.t.u. as fired, there remains an amount of heat, all of which a perfect boiler and furnace could utilize. The ratio of the amount of heat theoretically available to that contained in a pound of coal as fired is the ideal efficiency and should form the basis for all analyses of results.

The ratio of the amount of heat actually utilized to the amount theoretically available is the true measure of the boiler and furnace performance and is the only basis on which results can be scientifically analyzed. I term this ratio the "actual efficiency" of boiler and furnace.

The ideal efficiency for the Kewanee test is about 89 per cent. The combined efficiency of 80.95 per cent is, therefore, about 91 per cent of that theoretically possible and 91 per cent is, therefore, the real measure of the performance or actual efficiency of the unit.

Judgment of furnace and boiler performance on a basis of the total heat in a pound of coal is really an unfair proposition and I propose to remove all handicaps and put everyone back to scratch by basing furnace and boiler performance on the theoretical maximum. Advantages or disadvantages due to moisture and hydrogen in the coal, boiler pressure and atmospheric temperature are thus eliminated and a true comparison is expressed by the actual efficiency.

If further analysis of a test is desired, the furnace and boiler losses may be considered separately and the individual performance of each determined, but in any event, the performance should be based upon the heat theoretically available per pound of coal as fired, rather than upon the total heat in a pound of coal as fired.

The evidence is all in favor of accepting the actual efficiencies at Kewanee instead of those as corrected and this is directly in line with my own experience that at high rates of combustion the unaccounted-for loss increases rapidly, unless an unusually large furnace is provided. This often limits the range of efficient operation. The Kewanee tests differ from the Detroit tests in that at Kewanee the most efficient furnace capacity was exceeded at about 120 per cent of rating, whereas at Detroit the limit of efficient furnace capacity was not reached at 200 per cent. The most noticeable point of excellence at Detroit was the large combustion chamber, whereas at Kewanee it was the low flue gas temperature.

The question of unit efficiency, or rather range of unit efficiency, is of great importance on account of its bearing on station economy. If a whole station is to be operated economically, it is essential that the capacity-efficiency curve of a unit be known, and a series of carefully conducted and analyzed tests is necessary to establish this curve.

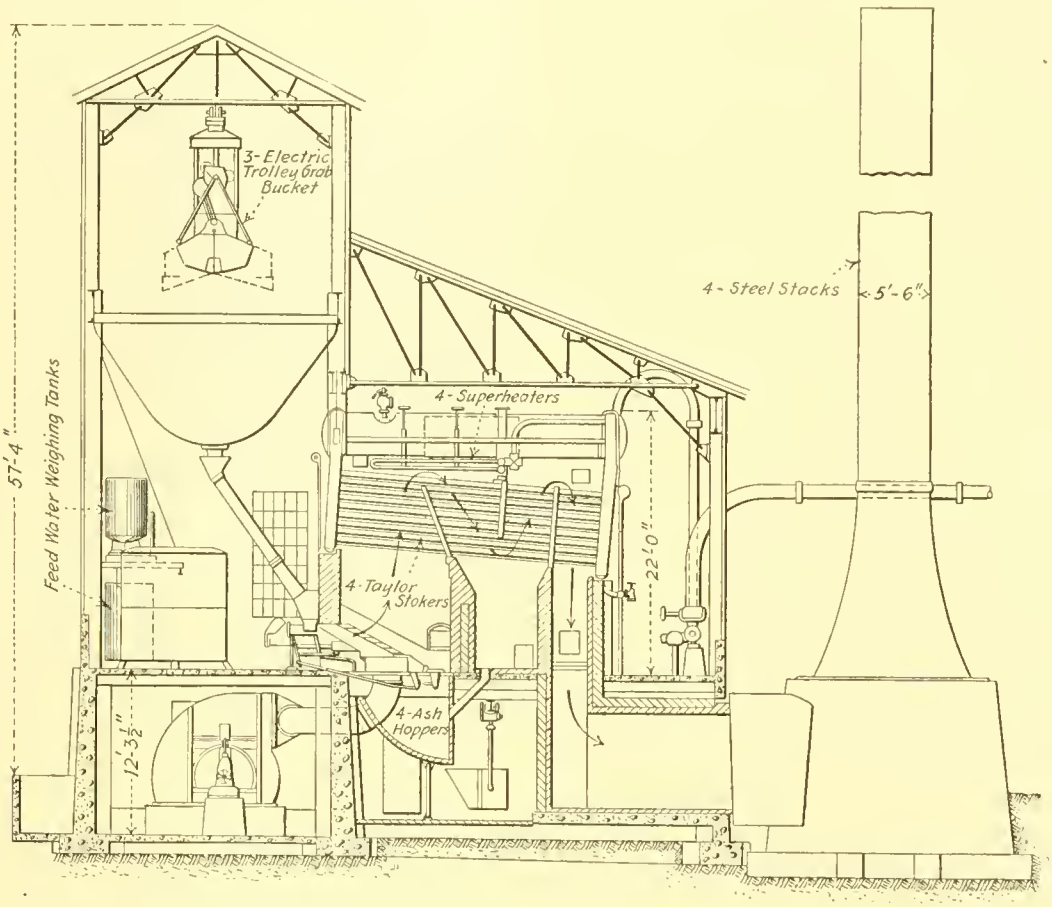


Fig. 2 Cross Section of the Kewanee Boiler House, showing Arrangements of Boilers and Auxiliaries

The amount of coal required to keep a boiler banked must then be accurately determined. With this information and the boiler room load curve before him, the engineer is able to establish a scientific schedule of operation.

The number of boilers in service should be such that each operates at or near its point of maximum efficiency, if the load on the entire station is practically constant, but as this is seldom the case, a certain range of unit capacity is necessary. When the point is reached where further decrease in unit capacity causes a decrease in efficiency which will more than offset the loss of banking one boiler over the period of low load, banking should begin. With increasing load, additional boilers should be put on as soon as the load becomes large enough to permit their efficient operation. This affords protection against an unexpected or early increase in load by keeping as many boilers as the line can operate efficiently and also has every boiler thoroughly warmed up and all fires in good condition before the peak load comes on. For short peaks it will usually be found most economical to drive boilers to their maximum capacity, even if this is above the limit of efficient operation.

After a schedule of operation has been developed, it is then necessary that each unit be operated as near to the test conditions as possible. The test conditions of draft, gas analysis, flue gas temperature and combustible in the refuse should be maintained as nearly as possible and this can be done only by keeping continuous and accurate records and immediately locating and rectifying any condition that is not right. Records of coal burned and water evaporated should also be kept and the cause of any decrease in the evaporation followed up and removed. It is only by such methods that continuous maintenance of most efficient conditions is secured and in view of the fact that many boiler rooms having up-to-date equipment operate at between 50 per cent and 60 per cent efficiency, the importance of such methods of operation cannot be denied.

A high efficiency test, like the one under discussion, does not guarantee low steam cost in yearly operation. The fight is only well begun. Of greater importance is the maintenance of those conditions that contributed to the high efficiency recorded. The apparatus here described could be so operated as to offset its inherent efficiency, so that the annual steam cost is really a factor, not only of the apparatus efficiency, but of the efficiency of the boiler room organization, which organization is extended to include the man paying the bills.

H. Boyd Brydon thought that there was little doubt that on the 72-hour test No. 12, a gross efficiency approximating closely 81 per cent was actually obtained; but, before this figure could be used for purposes of comparison, account had to be taken of certain items, of which no mention was made in the paper, which had to be charged against this efficiency. One was the steam consumption of the engines operating the stokers, fans, etc., used for burning the coal. He hoped that Mr. Bannister would be able to add to his paper information as to the steam consumption of this auxiliary equipment. Several approximate figures have been given from time to time as to the steam consumption of this type of stoker equipment, varying from 2 per cent to 4 per cent of the steam made by the boiler. In tests[1] of very large boilers at Detroit made by Dr. Jacobus, the steam used by the stoker and its auxiliaries varied from 2.61 per cent to 3.41 per cent in a series of seven tests, or an average of 2.78 per cent. It would seem that approximately this percentage should be deducted from the apparent efficiency of the combined apparatus, since the amount of steam thus used was not commercially available.

It was not an answer to state that the exhaust from these various auxiliaries could be put into a feedwater heater, and most of the heat thus recovered. We were not interested here in a plant test; we were interested in the results as a boiler test and the steam consumption for this apparatus was greatly in excess of that required for operating some other types of stokers, chain grates for example.

The results further appeared to be open to some correction in the matter of the amount of the radiation and miscellaneous losses. On checking the results with the Taylor stokers at Detroit against the figures here given, it was noticeable that radiation and miscellaneous losses at Detroit averaged about 3.3 per cent for tests at approximately the capacity obtained in test No. 12 (see Table 16, Dr. Jacobus' paper); for the Kewanee test, this item was given at 2.49 per cent. It was possible that radiation loss in the Kewanee tests was less than was the case in the Detroit tests, on account of the exceptionally careful manner in which the boiler setting was lagged. On the other hand, the relative furnace volume in the Kewanee tests was very much smaller than in the Detroit tests as pointed out by Mr. Harrington, which would inevitably materially increase the unaccounted-for loss aside from radiation.

Fig. 3 View of Interior of the Boiler Room

Another item which entered into the costs of obtaining the efficiency given, which should be deducted in order to obtain the net efficiency of the process, appeared to be the amount of steam used in the soot blower. The speaker wished to be informed as to the frequency with which these were used during the 72-hour test and the length of time the valves were open; and if possible, the approximate amount of steam used in keeping the boiler clean.

In explanation of the efficiency obtained advantage was

[1] Tests of Large Boilers at the Detroit Edison Company, D. S. Jacobus, Trans. Am. Soc. M. E., vol. 33, p. 565.

claimed for the low steam pressure employed. In test No. 12, the average steam pressure was 117.6 lb. gage, or the boiler water was approximately at a temperature of 349 deg. fahr. The low temperature of the water in the boiler naturally promoted efficiency by rendering possible a low flue gas temperature, but this could be used only as indicating the necessity for correction before the test could be compared with others, as most of the important power houses of the present day are operating at pressures greatly in excess of this. Assuming the same difference in temperature between saturated steam and flue gas, as in test No. 12, approximately 63 deg. fahr., the final flue gas temperature for boilers operating at 200 lb. would have been about 450 deg. fahr. The effect of this would be to increase several of the losses by an amount aggregating approximately 2 per cent.

While, therefore, the low steam pressure operated advantageously in this case, he thought that it could not be considered to be practically useful, as the value of the higher pressure in reducing steam consumption would very much more than offset the improvement in boiler efficiency.

If we apply the Detroit figure for radiation and miscellaneous losses and for steam consumption of the stoker equipment, and correct the results for increased steam pressure, it would appear that 81 per cent should be reduced to approximately 75½ per cent. Such an efficiency obtained with western coal was an interesting result and one which must have afforded the designer of this equipment great satisfaction. The figure possibly represented about 5 per cent higher efficiency than was accomplished in every-day practice in some of our large western power stations under similar conditions. It therefore became of particular interest to ascertain the cause of this improved economy, speaking of the test simply as a boiler test, not as a plant test.

Two things appeared responsible for the improvement shown. The principal item, it was believed, was the use of a four-pass setting; the second was the vary careful lagging of the boilers. It was to be regretted that further information was not presented in the paper that an estimate might be made of the importance of these items. Unquestionably the use of a four-pass boiler was an economical improvement.

From data at hand it would seem that considered as a gas cooler, the use of four passes might result in an improved economy of about 2 per cent, as compared with three passes. If this were true, there remained about 3 per cent improved economy, which presumably should be credited to the stoker. There was some doubt in the writer's mind as to whether this difference would in every-day operation actually show any material saving over the chain grate when the fixed and operating costs of the very much more expensive equipment were considered.

It was generally understood that in the case in point, important economies had been effected as compared with the results obtained in normal operation of the pre-existing boiler plant. This was entirely probable and would be expected with any modern boiler plant in comparison with an old plant. In the speaker's own experience, monthly operating figures in a somewhat similar case had shown that with a reconstructed boiler plant, double the load was carried for the same coal cost.

If Mr. Bannister would favor us with data on the cost of repairs on these stokers, also on the means taken to prevent the accumulation of clinker on the side walls of the furnace and on the ease or difficulty of cleaning the fires and removing ashes and clinker, the information would be of value and would enable comparison to be made with other types of furnaces burning similar coals.

R. H. Kuss (written). The paper prepared by Mr. Bannister deserves special consideration from the fact that it brings forward definite information respecting a combination of a boiler and furnace, previously untried in the Middle West where a coal of comparatively low native heat value is encountered. Considerable experience with the combination has been accumulated in the Eastern States with high-grade bituminous coal, so that the novel features encountered in this series of tests spring really from the kind of coal employed rather than from any other feature.

Even without correction or adjustment the efficiency results are exceedingly good. It is, however, profitable to analyze the results so that whatever benefits have come about may be properly distinguished and located. Certain critical items of the series of tests can be picked out to advantage. One of these is the low gas exit temperatures which argue a high percentage of heat absorption; or, in other words, high true boiler efficiency. This is particularly accounted for by the baffling.

During the 72-hour test, No. 12, temperature readings were taken regularly at points above and below the fourth pass. The averages of the calibrated readings showed a temperature difference of 67.4 deg. fahr. which indicates a heat absorption of a little above 2 per cent of the heat value of the fuel.

If it is conceded that the last pass is responsible for this amount of heat saving, there is still to be accounted for a very appreciable amount above that usually encountered with standard three-cross pass boilers. The conclusion is inevitable that the baffling of the first three passes contributes in no small degree to the general high efficiency results, or a temperature as low as 470 deg. fahr. would not have been encountered at the end of the third pass, even crediting the setting with special provisions against radiation and air leakage. It is clearly shown that for good absorption results, 18 ft. tubes are not necessary for three-cross pass boilers, provided the baffling is such as to employ the heating surface to advantage. I believe that one of the most important items of design is the selection, in this installation, of an inclined flame plate instead of the usual flame plate at right angles with the tubes. Fig. 1 of Mr. Polakov's paper on Task Setting for Firemen[1] can be studied to advantage in connection with the baffling employed at Kewanee.

It is obvious that the tube proportions could not have been duplicated without the inclined first flame plate, and this test series, combined with the close scrutiny of many other four-pass installations, causes us to conclude that it is not possible to create a successful four-pass setting with all of the baffling at right angles with the tubes, even when using 20 ft. tubes unless it is understood that the setting is to sacrifice a large part of its elasticity in capacity possibilities. If this conclusion is correct, then the next question to be determined is an adequate security against baffle leakage and general baffle deterioration. The use of tile resting against metal supports in an inclined position is not successful in the construction of the inclined flame plates. Recourse is best taken to building the first flame plate especially by the

[1] The Journal, Am. Soc. M. E., December, 1913, p. 1734.

older, more costly and perhaps less attractive method of "grouting" in position baffles made up of plastic refractory material reinforced with metal as was done in the installation at Kewanee. That this method made possible the location and protection of soot blower pipes is worthy of note, though the main reason for the selection of this construction came from a desire to create a tight baffle in an inclined position.

A study of the draft losses in the boiler as a whole permits interesting speculation, though it is unfortunate that no analysis of the draft throughout the setting was possible, owing to avoidance of soot dusting doors or special openings for that purpose. Based on observation taken in other installations, it may be stated with accuracy that the draft losses in a four-cross-pass setting for a boiler of a given size, using 20-ft. tubes suitably baffled, is no greater than for a three-cross-pass setting for a boiler of the same size. It is accounted for by the fact that in the three-cross-pass design, needless or useless draft losses are created before the gases enter the damper frame; in the vertical exit around drums, because the areas are placed at a disadvantage to the natural direction of gas travel and in the rear exit type, owing to the necessity of the gas passing through a great many rectangular openings between circulating tubes placed before the damper opening.

In order to apply the foregoing statement, it is well to note that the first flame plate must be in an inclined position with respect to the tubes and not at right angles with the tubes when dealing with the four-cross-pass arrangement. I wish to point out that the same draft intensity at the damper frame is not provided for the same chimney proportions, comparing the two types of installations, owing to the lower gas temperatures in a case of a four-pass boiler; therefore, to make possible the same draft intensity at the furnace or at the damper opening, the draft-creating facility should be increased for the four-pass scheme by an amount at least equal to the temperature difference equivalent in chimney height.

It is worth comparing the proportions of two installations of the same size, using the Kewanee design as one, and the more familiar three-cross-pass boiler setting of the same furnace width as the other. Such a three-cross boiler of approximately the same horsepower would have 312 four-inch tubes 18 ft. long; there would be two drums instead of three, lest the gas passages around the drums be too much restricted in area. It is, of course, possible to select a wider boiler not so many tubes high to obtain the same horsepower rating, in which case the areas around the drums would be larger but still not large enough to afford ample space for the use of three drums.

The ratios of the dimensions of two such boilers would be as follows:

	Kewanee Boilers	Typical Three-Pass Boiler
Heating surface, sq. ft.	6130	6200
Height of setting	19 ft. 10½ in.	20 ft. 9 in.
Width of setting	15 ft. 7 in.	15 ft. 7 in.
Length of setting	23 ft. 0 in.	21 ft. 0 in.
Contents of setting, cu. ft.	7130	6758
Contents water and steam space, cu. ft.	1064	929
Contents water space, cu. ft.	825	766
Contents steam space, cu. ft.	242	163
Steam disengaging surface, sq. ft.	192	127

These figures show little difference in the setting dimensions but a rather large difference in the cubical contents of the two types of installations. Where the water conditions are severe the importance of these proportions are quite manifest.

Aside from the greater economy in the absorption of heat due to four passes in place of three passes, several other important advantages are:

a The breeching is below the boiler; consequently the boiler room may be somewhat lower than for a three-cross-pass setting; the breeching is out of the way of piping; heated air surrounding the breeching due to radiation can be carried direct to the furnaces beneath the boiler room floor; the boiler room is cooler.

b The cleaning of soot from tubes more effectively done because the gas passages are less in width.

c Where the plant arrangement permits, the space between the normal boiler room floor and the rear boiler header can be used for breeching construction. Almost the entire setting behind the furnace bridgewall is of little use in the three-pass setting; the brick cost, air infiltration and radiation losses of these walls can be largely done away with by constructing the breeching immediately behind the furnace bridgewall. By the same design there is created a boiler room floor level behind and between the settings, from which soot blowing, washing, blowing-down, etc., can be accomplished without the use of platforms or ladders. The disadvantage of two elevations disappears if the engine room floor is of a higher elevation than the boiler room, and provided that the engine room is located behind the boiler room. The setting cost plus breeching cost is less than for a normal three-pass setting plus a breeching.

T. A. Marsh (written). The wide variation in the analysis of coal reported in the Detroit Edison tests[1] suggests the desirability of reporting the analysis obtained by the National Tube Company in comparison with those obtained by Robert W. Hunt & Company for each sample. No mention is made of the type of calorimeter used in either laboratory.

It is mentioned that it was "possible to properly regulate the air supply by observing the smoke condition," but this smoke condition is not defined; in Chicago we are very interested in it. From observations of similar settings, the writer would expect objectionable smoke except at low ratings, and I would inquire as to the performance in this regard. At what ratings would the stack violate the Chicago ordinance? It may be possible when individual stacks are used to regulate the stoker by the smoke, but the inconvenience of observation from the firing floor and the restricting smoke ordinances in most cities present objections to this practice.

I should like to inquire as to the steam consumption of the fan and stoker engine. On the Detroit Edison tests this item varied from 2½ per cent to 3½ per cent of the total steam developed. It would be interesting to know if the western fuel conditions cause any increase in this percentage.

No mention is made in this report of maintenance costs. It is quite possible that the installation has not been in operation a sufficient length of time to reach conclusions. However, the maintenance cost of this type of stoker is high

[1] Tests of Large Boilers at the Detroit Edison Company, D. S. Jacobus, Trans. Am. Soc. M. E., vol. 33, p. 565.

whenever pressure in the furnace chamber is obtained. The record submitted indicates the probability of pressure in the furnace as the average furnace suction in test No. 12 is indicated as low as 0.011 in. water, and to obtain an average so nearly neutral some observations must have indicated actual pressure in the furnace.

The New York Edison Company have repeatedly been reported by the press as having spent one-half million dollars for cost of equipping stack connections with cinder catchers to avoid a nuisance resulting from high forced blasts on stokers of the type being discussed. This company claimed at times as much as 3 per cent of their fuel was passed out of the furnace and lost as far as heating effects were concerned, 2 per cent of which was deposited in boiler passes and breechings and 1 per cent was actually discharged from the stacks. If such results occurred at Kewanee some of the heat balances reported are impossible.

A. Bement[1] wished to know whether the total or the available hydrogen contained in the coal was considered when calculating the loss, due to the water formed by this constituent in the products of combustion. He also asked how the fires were cleaned and how often. He expressed his opinion that the high results that were generally attained at the present time with boilers under test were due more especially to improvement in furnace design and in operation than to any of the other factors. Except for CO it was impossible to determine the loss due to combustible elements in the stack gases. Hence this item of loss had been charged to radiation, or radiation and unaccounted for losses, which made the matter of radiation a factor of very elastic proportions. He also commented on the fact that the tendency was to get low heat measurements with low capacities and high measurements with high capacities, due to the changing of the center of gas travel with different velocities and volumes. He stated that the question of the number of passes in a boiler was an important study and that the present tendency seemed to favor the four-pass arrangement as opposed to a lower number. He had designed a five-pass boiler with 18-ft. tubes, although he thought in such a design a 20-ft. tube would be more desirable.

F. G. Gasche[2] (written). In reviewing the paper by Mr. Bannister, a higher appreciation of the results will follow the consideration of the difficulties attending the use of Illinois fuels high in ash and moisture content. These elements of a fuel are not simply inert materials so far as heat value is concerned, but they constitute a decided encumbrance in the effective utilization of the combustible matter. This detrimental influence of ash and moisture is being recognized by the growing practice of assigning a "figure of merit" to a given fuel such that the heat content is not the sole basis for estimating its value in commercial applications.

The success of Mr. Bannister in using a coal containing approximately 20 per cent ash and 15 per cent moisture with the accompanying boiler and furnace efficiency exceeding 80 per cent is probably without precedent in steam engineering in this region. Analysis of the heat balance for the 72-hour test reveals that the several elements leading to a higher boiler and furnace efficiency have been considered with unusual care. The exhibit is sufficient to warn the designer against radiation losses, high stack temperatures, poor furnace conditions and every other indulgence of past installations.

The especial precautions in the way of numerous corrections to leading results have the merit of strict conformity with the A. S. M. E. Code for conducting boiler tests. The application of these corrections will, no doubt, continue with due respect to their origin, but it would seem worth while to consider the measure of the performance of a boiler as a physicist would look on such an experiment. In this way a boiler test is to be considered chiefly as a measure of *rates* of delivery of coal, water and heat.

If the accumulating deliveries of fuel and water are recorded graphically with possibly hourly corrections for water levels, etc., there can be shown two curves for which an average inclination can be assigned. The *rates* of delivery of coal and water thus established would scarcely be affected by the corrections ordinarily applied to aggregate results of a boiler test. For nearly all purposes they could be ignored. This manner of deriving the results of boiler performance would eliminate or at least minimize the effect of conditions in the furnace at the start and at the finish of the test, which conditions frequently impair the significance of total quantities.

About ten years ago I succeeded in obtaining 78 per cent overall boiler and furnace efficiency by the use of dust fuel and a special type of furnace in connection with a water-tube boiler. Owing to difficulties in maintaining the furnace construction the process did not, at that time, develop into a commercial success, but the investigation was one of the early indications that, providing proper furnace conditions, it was possible to burn Illinois coal with its encumbrance of 18 per cent ash and about 14 per cent moisture with an excess air supply scarcely exceeding 12 per cent of the theoretical requirements of the fuel. Speaking as an individual, since I cannot claim the especial espionage or guidance of directive agencies in the steel business in the analysis of any phase of the power plant question, I will say that there are a number of steam boiler plants in the steel business where very commendable results are obtained. In coöperation with four engineers in lines of endeavor similar to my own I have had the privilege and the responsibility of reporting upon the physical condition and ostensible performance of a great many boiler plants connected with steel manufacturing. There are a number of such plants where the average monthly performance shows an overall boiler and furnace efficiency somewhat exceeding 70 per cent.

J. C. Bannister[1] (written). As the individual upon whom rests the responsibility for the actual economy of operation of this boiler plant, I am not so deeply concerned with what form the efficiency curve would assume under certain conditions, which have been suggested, or with what the discrepancies between government reports of the value of the combustible in Fulton County coal and the value of the combustible in the coal which was used in these tests, as determined by our actual analyses, were; but I am deeply concerned in the actual daily operating efficiency of this plant and the actual amount of coal, such as it is, which is being consumed. For this purpose, and anticipating some questions along this line, a very careful record has been kept during the months of October, November and December, cov-

[1] Consulting Engineer, 206 S. La Salle St., Chicago, Ill.

[2] Mechanical Engineer, Illinois Steel Company, Chicago, Ill.

[1] Manager, National Tube Co., Kewanee Works, Kewanee, Ill.

ering the actual operation of this boiler house, with a calculation of the evaporation and coal consumed per boiler horsepower-hour during those months. I have these figures before me, but before giving them to you I think it would be well to state to you what the real problem was which confronted us when this boiler house was designed.

First of all, our loads are practically constant for any one day of operation. We have a slight increase during dark weather and during the winter months at morning and evening, due to the lighting load, but the load curve is comparatively flat throughout each working turn. For this reason it was not necessary to take into account so strictly the capacity of the proposed installation for handling enormous peaks by running the boilers at extreme overloads, as it is in the case of lighting and railway plants. We had to provide for a maximum demand of from 2700 to 3000 boiler horsepower, using only three of the four boilers at any one time. This meant that at the worst no boiler would be called upon to develop more than $166^2/_3$ per cent of its rated capacity. We also knew that we would be obliged to burn a fuel in the form of slack, which at the very best would not contain more than from 9300 to 9700 B.t.u. per lb. as fired, and that this fuel would contain from 13 per cent to 16 per cent moisture and from 19 per cent to 22 per cent ash, with about $4^1/_2$ per cent hydrogen and $3^1/_3$ per cent sulphur. We also knew that it would be possible, on account of the nature of the prime movers in the plant, to use only a limited amount of superheat and very moderate pressures, and that the only exhaust steam available for feedwater would be from the pumps and fan engines. Considering all these things, the apparatus which was selected, and which has been described in this paper, seemed to us to be most suitable to our needs. It may be that equally good results could have been obtained with other equipment, with this same fuel, but I question whether it has ever been done.

The tests which were made last spring were, as the author has stated, for the purpose only of proving contract guarantees, and were admittedly too short to be used as a basis for final conclusions. They were, however, of such a gratifying character that we have been importuned by not only interested parties, but many disinterested parties, to give the results publicity. Before doing so we felt it necessary to conduct the test which was made in October, and which was of sufficient length and so surrounded with all of the possible safeguards as to make us feel sure that the result obtained would be unquestionable. The author has given these results in his paper, has pointed out what seemed to him the operating causes for the high efficiency, and has also suggested some possible conclusions which may be arrived at from this test under conditions somewhat dissimilar from those under which the test was conducted. Whether he is right in those conclusions or not may be a question in some minds, but I think there can be no question as to the conclusions reached upon the test itself. Furthermore, I am glad to be able to report that the operations during the three months of which I have spoken, October, November and December, have also shown very gratifying efficiencies. The figures which follow are compiled from the accounting department's records for these months.

First, as to the evaporation: We have two checks upon the water fed to our boilers. In the first place it is all measured through venturi meters which have been calibrated by weighing tests and the integration of these meters is corrected for temperature and a slight inherent error. We compare these meter readings with the actual measurements of water fed to our purifying plant, which is an intermittent system and into which the water is correctly measured in 60,000 gal. units. The discrepancy between the results obtained through these two methods is surprisingly small. From the total water fed thus obtained we deduct a certain amount, which has been predetermined by experiment, for the water blown down and used in refilling boilers; and thus obtain, approximately, these amounts of water actually evaporated for the respective months: October, 26,514,200 lb.; November, 19,278,750 lb.; December, 20,428,550 lb.

On our coal we also have two checks. One of these is the actual weights of coal delivered to the boiler house as taken from the mine weights and the weights reported by the official weighmaster at Kewanee, deducting at the end of each month the excess on hand over stock inventoried as on hand at the beginning of the month. Second, we have found during the entire period of all of the tests which we have run, covering altogether 172 hours, during which coal was actually weighed, that the total weight of coal so weighed to the stokers divided by the total number of revolutions of the stokers resulted in a constant factor of $110^1/_2$ lb. Each stoker is equipped with a revolution counter, and readings are taken from these counters daily. At the end of the month the aggregate revolutions multiplied by $110^1/_2$ gives the total amount of coal fed to the stokers. It may be a surprise to learn that the discrepancy between the calculated weights as derived from the shipping weights and the monthly inventory, and that derived from the revolutions of the stokers, has been for the three months in question less than 1 per cent of the total.

From these data the water fed to the boilers, as determined by the methods described above, and the coal as determined by the methods just cited, we arrive at the coal consumed per boiler horsepower-hour for these three months, which has been: 4.53 lb. in October, 4.71 lb. in November, and 4.49 lb. in December. The average evaporation for the three months per pound of coal fired was 6.902 lb.

Now, using the same figures for water and coal, and allowing to the coal as fired an average value of 9500 B.t.u. per lb., the operating efficiencies have been 77.7 per cent in October, 76.3 per cent in November, and 78.5 per cent in December. The actual hours during which these boilers were fired during these three months were 1165, 1077 and 987, aggregating 3229 hours, which is only 49 per cent of the total hours for three boilers during those three months. When it is considered, also, that the three months in question were not ones of the highest activity in our business, so that while three boilers were in use on some days and only one on others, and that it was only necessary to fire one or two boilers at any time during the night turns, all of which added to the standby losses during this period, I think it will be admitted that the operating efficiencies have been fairly satisfactory and compare favorably, conditions considered, with the efficiency obtained in the 72-hour test. While we realize that our former steam plants were by no means economical, personally I cannot help feeling a sense of pleasure in the fact that this installation has already begun to save us in the matter of fuel alone at the rate of at least $30,000 per year, or at the rate of more than $10 per horsepower-year.

THE AUTHOR. If we could incorporate Mr. Harrington's

"ideal or actual efficiency" in the boiler code, as advanced by The American Society of Mechanical Engineers, I would be greatly pleased, and am ready to use such a standard for all boiler tests. Whether or not the theory advanced by Mr. Harrington that the radiation and miscellaneous loss increases with the load is correct, I frankly confess a lack of knowledge of flame propagation which would decide this question. However, it is hardly logical to use the actual radiation and miscellaneous loss for each test, as these figures are based upon tests which are admittedly too short to be reliable. We know that this item of radiation and miscellaneous loss is made up chiefly of two losses: one due to radiation from exposed surfaces, the second due to unconsumed hydrocarbons. The first loss is certain to increase with the load, if expressed in absolute heat units, but when expressed in percentage of heat in coal burned, the loss decreases with the increase in rate of firing. The second loss is indeterminate as it cannot be measured by the usual test methods. This second loss may or may not increase with the load, depending upon the nature of combustion in the combustion chamber, and whether or not the maximum furnace efficiency or combustion chamber efficiency was exceeded in these tests is an open question. However, both the actual and created efficiency figures are submitted in the report so there need be no serious difficulty arising from this point of disagreement.

I do not know what the steam consumption of the fan engine was. As these tests were conducted to determine only the boiler, furnace and stoker efficiency, the net efficiency of the plant was not considered. Had the net efficiency of the plant been considered I would still disagree with Mr. Bryden in his statement that from 2½ per cent to 3½ per cent should be subtracted from the efficiency figures as shown, due to the steam consumed by the fan engine, as this steam after losing perhaps 7 per cent of its heat energy is delivered to the feedwater heater, which consumes all of this steam. Thus a very small portion of the fan engine steam is lost as that heat which is put into the feedwater would otherwise be supplied by the boiler for which coal would be burned. In some instances where sufficient exhaust steam is available to heat feedwater without the use of exhaust from the fan engine, there would be an appreciable loss, due to this steam consumption, but I believe that each case must be considered separately in order to establish the value of steam used by fan engines. It would also be logical to consider steam consumed by feedwater pumps in figuring the net efficiency of the plant.

Since the tests were made the steam consumption of the soot blowers has been found to be at the rate of 43,200 lb. per hour per boiler. The tubes on each boiler are blown for about 10 seconds at a time at 8-hour intervals, which gives a total consumption of 360 lb. per boiler per day.

Little or no difficulty has been experienced in handling ash or clinkers since the method of handling has been worked out and a system adopted which allows for dumping before a hot clinker has worked across a dumping plate and become glued to the bridgewall. It would be a very simple matter to make this clinkering a burdensome process if the proper time for dumping the clinker were not observed. As to the frequency of dumping, the following figures will serve to illustrate approximately:

"Ash and refuse represents approximately 25 per cent of dry coal fired, and 1100 lb. of ash are dumped at each cleaning period. Thus approximately four times as much weight in coal is fired as is represented by the weight of the ash, or 4400 lb. of coal per period of cleaning. Knowing the rate of firing, the length of cleaning period may be established."

As stated in the text of the report, pop-offs occurred through the pop-valves on the boiler proper, although there is a pop-valve on the superheater outlet, which originally was set several pounds below the valves on the boiler proper, but due to a slight accident to this superheater valve it was not set in this way for the tests.

Contrary to Mr. Marsh's belief, that objectionable smoke occurred except at the lowest loads, it may be stated that with the increase in load the ease with which no smoke may be maintained is increased. At no load was it at all difficult to maintain combustion without any apparent smoke. However, I have found that the point of most efficient combustion occurs when there is a slight haze of smoke over the stack, which shows up as the amount of blast is reduced after the fire has been burning without smoke. No trouble has been experienced in blowing cinder out of the stack. Considerable fine ash is blown over the first baffle and some is carried to the base of the stack, but we have observed no similar deposit of ash outside the gas passages.

Answering Mr. Marsh as to the kind of calorimeter used in analyzing the coal, R. W. Hunt & Company used a Mahler-Atwater oxygen bomb, and the National Tube Company a Parr calorimeter, which has been thoroughly checked by standard methods and which gave figures that compared very well with those given by R. W. Hunt & Company, on similar coal samples.

In calculating the heat loss due to burning hydrogen in coal, the total hydrogen was used as we had this figure from our ultimate analyses but had no analyses which showed the chemical combination of this hydrogen with other elements.

One of the chief items of saving made possible by the installation of the boiler house described in this report was that of labor. During the 12-hour day shift one man handles all the coal and ash that must be handled for the 24 hours. This means removing all the coal from the cars and placing in the bunkers, and removing ash from bunkers under stokers, and placing in cars for shipment. There are at all times two men upon the boiler and auxiliary room floor. Thus we have during the 24 hours five men who do all the required work in connection with this plant, including cleaning idle boilers and small repairs, each man working 12 hours.

LARGE STEAM POWER PLANTS

Abstract of Topical Discussion Presented at the Chicago Meeting, March 18, 1914, by I. E. Moultrop, J. W. Parker, John Hunter and W. L. Abbott

I. E. Moultrop's talk concerned the boiler room, to which the present-day engineer is directing a great deal of attention to secure better economy. This is as it should be, because the operation of the boiler room will show in increased fuel economy the increase of skill and intelligence devoted to that part of the plant.

The majority of plants are subject to great and sudden variations in load. In the electrical end of the station there are all sorts of instruments which are closely accurate, but only recently has some thought been given to installing instruments in the boiler room. Originally, all that a man had was a water glass and a steam gage. A visual load indicator was then added and the next instrument was a device that has created a lot of discussion, the CO_2 recorder. This is a delicate instrument, and where it has been put into the boiler plant and received the best of care and attention, it has been of some use. But it is naturally a laboratory instrument and not for the average fireman. The difficulty is to get a fair sample, as the qualities vary greatly in different parts of the cross-section of the gas passage. A sample taken from one place may be very different from that taken from another point in the same flue at the same time.

One of the most satisfactory instruments now in use is the steamflow meter. Using it in connection with draft gages, draft regulators, feedwater regulators, etc., the fireman can operate a boiler plant with much intelligence.

In the usual large station a high chimney is necessary to carry off the gases. Ordinarily the height required for this purpose is enough to give the draft needed under normal conditions. But the exacting requirements of public utility plants call for more positive control over the draft, and ability to meet sudden demands for load calls for forced-draft apparatus.

A good arrangement is a plant that will run on natural draft, with some cheap apparatus for increasing materially the draft to meet peak loads or unexpected demands. At the L Street Station in Boston the situation has been met by using Murphy stokers, closing up the ashpit and creating forced draft with steam jets. The load is carried on natural draft up to 150 per cent of rating. Above that the ashpit doors are closed, the steam blower turned on and it is possible to reach 300 per cent of rating, or over. Boilers have been taken from 125 up to 300 per cent inside of 5 minutes.

In the past too much attention has been given to the operation of the turbine or engine room and not enough to the boiler plant. The usual practice has been to put the high-priced and high-grade engineer in charge of the generating room and hire some brawny individual to shovel coal into the boiler. The economy of the turbine room is mostly in the hands of the designing engineer. In the fire room the constructing engineer does not have much control over the economy. When it is considered that from 60 to 70 per cent of the cost of putting a unit of electrical energy upon the bus bars is spent in the fire room it does seem that this is the place to have the most skilled help. The fire-room job has been dirty, under-paid, uncomfortable, unpleasant and unattractive in every respect. The mechanical stoker has changed this in many respects. The boiler room should be arranged to do away with all of the manual labor, make the place light and clean, and give the man in the fire room sufficient instruments so that he can tell what he is doing. This will make the job attractive to a young man and it will be possible to get better help in the fire room.

J. W. Parker spoke of the immense units at the Delray plant of the Detroit Edison Company and their operation, and those to be installed at their new station at Conners Creek. It was his opinion that the large boiler had created a good deal of criticism just because it was large. Some people object to putting so many eggs into one basket, but quoting from Mark Twain, he preferred to put them all into one basket and watch the basket. Boilers are more reliable units than steam turbines. It is possible to lose a large turbine much quicker than a large boiler. The company had never lost one of its large boilers when it was needed, and during a peak, never had a tube burst.

As to tube troubles, the water was not very bad. In a year or 18 months, upon opening a boiler about $^1/_{16}$ in. of sulphate scale was found on the front tubes. With a unit driven only during the peak at about 175 per cent of rating, $^1/_{16}$ in. of scale is not serious, but with the double-ended boiler the trouble from radiation seems to be greater. Everything is radiating right at the front tubes and when running at 200 per cent of rating very little scale is permissible. The only trouble in this direction had been a small bag about the size of a quarter and this was not discovered until the unit had been cut out and inspected.

Even $^1/_{16}$ in. of scale is too much to stand for, however, and the water should be cleaner. A small amount of barium hydrate had been used but Mr. Parker was in favor of using distilled water for make-up. It does not cost much except the radiation from the distilling apparatus because it is possible to distill the make-up under vacuum. By using it the amount of blow-off can be reduced to 2 per cent. Trouble from corrosion can be lessened by feeding a certain amount of lime into the boiler.

In reply to a question by Mr. Hunter the speaker said that they had used compound much as people buy

Presented at the Chicago local meeting of The American Society of Mechanical Engineers on March 18, 1914.

and take patent medicine, getting enough foam to cause flooding of the superheater tubes and their constant burning. The barium hydrate is fed in the same way as any compound and it controls the scale formation in the same way, but avoids foaming. The barium sulphite precipitate was so fine that it could not be filtered out, and they were using a little sodium in combination with it, but this compound was simply used as a makeshift until the experiments on the practicability of using distilled water for make-up had been worked out.

One of the advantages of a large boiler is that the company can afford to use more instruments, employ better men and thus pay more attention to each single boiler unit.

The Detroit Edison has just started the foundations for a station of 120,000 kw. normal capacity. It will have 12 boilers of which each will ordinarily care for 10,000 kw., and there will be no spares in the plant. By installing forced-draft apparatus and by taking care that the stacks and breeching are ample, it will be possible to get 250 per cent of rating out of each boiler. Each turbine is served by two units and running at the above rate one boiler out of every four could be spared.

The boilers at Delray have done so much more than was expected of them that there is too much boiler capacity. During the peak season of 1913 no banked boilers were carried, which, of course, means a large saving. It is hard to realize how much of a disadvantage a low load factor is. Boilers which show high efficiency under a constant load will not show up as well under variable conditions.

To take advantage of the possibilities of large units it is necessary to study conditions. At Delray they started in with boiler tests and studied carefully the things that seemed to be indicative of good efficiency. In this connection the CO_2 machine has been a most valuable instrument. They had been able to keep it running and firemen trusted it. Samples are drawn from four different points in the setting and are mixed automatically to obtain an average sample. The recorder is mounted on the front of the boiler where the firemen can watch it. There are also steam-flow meters and draft gages, but Mr. Parker did not know of any better instrument than the CO_2 recorder to show good firing and poor firing conditions. The flame is watched where it leaves the furnace and enters the first pass. If there is a slight haze there it means that there is some slight flame over in the pass, and if it gets a little bit heavier there is danger that the gases will be cooled down and go out before the combustion is complete.

It is possible to get a beautiful looking combustion chamber and a good looking second pass by using an excess of air and still have bad combustion. There is no better way to detect it than by the use of the CO_2 machine. From 13½ to 14 per cent of CO_2 is obtained as an average when the boilers are running steadily. Conditions are disturbed a little about noon and the records show perhaps 10 per cent. As the boilers are run harder the CO_2 rises. It is common to get 16 to 16½ per cent at 225 per cent load, and checking with the Orsat, there is no more than a trace of CO. It is not a good idea to draw two lines on the CO_2 chart and tell the men to keep between them.

As at first installed the control apparatus of the big boilers was clumsy to handle. The damper was handled from a gallery 20 ft. above the men's heads. They had no steam-flow meter. Efforts have been made ever since to bring the control under the hand of the fireman so that he will have all the advantage that a testing engineer has when he is running a test on a boiler. The men can control everything from one point and all the instruments are on one board.

It has naturally come about that everything is hand-controlled and automatic regulation has not been tried because it was desired first to find out what there was to do. It would then be easy and desirable to install automatic apparatus.

With hand control it is possible for one fireman to handle two of these large boilers. In addition there is a roving fireman over every nine boilers. Firemen who have been in the service 2 or 2½ years are receiving 40 cents an hour and the company is rapidly getting to a point where the highest priced and brainiest men must be placed in the boiler room. Ordinarily a change from the boiler room to the engine room has been considered a promotion, but under the new conditions the engine room will have dropped to a secondary place. In making transfers it is important that the men realize this, as otherwise there is apt to be trouble and dissatisfaction.

As expressed by Mr. Stott at the annual meeting of the Society in New York, it would be a fine thing to have college graduates for firemen. This is not impossible by any means: the dirty work could be handed over to helpers and the real brain work entrusted to them. A preliminary training of this kind in the boiler room for a year would be invaluable and to the right kind of a man the job would be so interesting and worth while that he would be willing to do the actual firing.

John Hunter spoke of the construction and development of large steam power plants: In St. Louis this line of work has been arrested for the past two years due to the development of the large hydroelectric plant at Keokuk, from which 60,000 h.p. is transmitted over two transmission lines, at 110,000 volts, to St. Louis, a distance of 145 miles. At a substation in St. Louis County this is stepped down to 13,200 volts, 30,000 h.p. being delivered to the street railways company and 30,000 h.p. to the lighting company. The lighting company's energy is carried underground at this voltage, a distance of 7 miles, to a substation adjacent to the main steam generating plant, where it is stepped down to the steam-generating voltage of 6600. In the

steam station there are three distinct systems of service: the street railways 25-cycle, the Union Company's service for industrial power and business lighting, which is changed to direct current, and 60-cycle service for residence lighting. The water power energy is connected directly onto the present bus bars of the steam generating system, the two systems floating together in parallel.

To insure continuity of service the steam station has been maintained as a standby ready to pick up the water power load in the shortest possible time. The prime movers are either in on the bus bars, or floating, ready to pick up the load, which is an easy method of operation. The condition is much different in the boiler room. It was found from test that it would take 130 lb. of coal per hour to bank the fires in each boiler and hold it at about 60 lb. steam pressure, and as all of the boilers are equipped with chain grates, which are slow-moving units, it would require about 30 minutes to bring them in on the header with the fires in such condition that they could maintain the desired capacity.

To bring the boilers quickly into service at less cost a unique system of keeping the water hot in the reserve boilers with fuel set on the grates ready to ignite at a moment's notice was developed. A tank with a steam coil was placed in the basement directly below the battery of standby boilers. The blowoff headers from these boilers were connected to the bottom of the tank and the top to the superheater connections to the steam drums. The difference in elevation of these two connections to the boilers caused an easy circulation. The steam coil in the tank was connected to a drain of one of the main steam headers of the standby boilers which were kept alive for emergency service. This connection not only served to drain the header but also to heat the water for the idle boilers, and maintain it at a temperature of about 212 deg. fahr. at a cost by test of the heat equivalent of about 12½ lb. of coal per hour. The boilers can be cut into service and maintain their capacity in about 15 minutes.

Quick ignition of the fires has been solved by laying on the grates, which are 10 ft. by 10 ft., two rolls of oily rags, crosswise and lengthwise, covering the remainder of the grate with a high-grade washed nut coal about 1½ in. in size to a thickness of 9 in. Kindling wood soaked in oil is placed on the top of the coal. This fuel may stand any length of time without fear of deterioration or cost. On ignition it quickly bursts into flame and the generation of steam is thence rapid.

In maintaining hot water in standby boilers it is important to keep the dampers tight so that there is no circulation of air in the boiler. In this way the brick setting is kept hot. The fire brick suffers little from the heavy action of the flames when the fires are started. One complication which arose during the past six months was a pitting action in the drums. Most of this pitting was in the vicinity of the water line and evidently was the result of galvanic action between the metal of the boiler drums proper and particles of carbonaceous matter adhering thereto. Further action was prevented by cleaning out the corroded spots, scraping and wire-brushing the entire inside of the drums and applying two coats of graphite paint, permitting each coat to dry thoroughly.

To prevent the possibility of further action of this sort, the method of treating the boiler feedwater was changed. The plant in St. Louis is on the banks of the Mississippi River, which contains a high percentage of silt, sand and organic matter. This water is clarified for boiler purposes with a coagulent of lime and sulphate of iron, adding a small percentage of soda ash to relieve it of its permanent hardness. The use of this soda ash results in the concentration of sodium sulphate in the boilers, and as this is strongly alkaline, it was thought that it served as an electrolyte for the galvanic action taking place between the particles of carbon and the iron. The company has just begun using barium hydrate instead of soda ash to remove all of the organic matter and a large portion of the sulphate, or permanent hardness, from the water before it enters the boiler, at the same time avoiding the presence of an alkaline solution in the boilers.

Mr. Hunter then referred to an experience with the cooling coils in the high-tension transformers of the hydroelectric system. The coils in these transformers were of iron, and although the current was alternating it was found that the coils were in a strong magnetic field and were highly magnetized. After being in service for six months the inside of the coils had deteriorated rapidly, indicating galvanic action. The pipes had also become heavily coated on the inside with mud, which had been deposited from the water flowing through them. The deterioration and accumulation of mud forced a change from iron to brass coils in the transformers and in these there is no accumulation of any kind.

The effect water-power operation had on the coal supply on the St. Louis market is interesting. A year ago at the Ashley St. station before the water-power service went into effect, something over 1100 tons of coal per day was burned; now only one-half of that amount is used. This falling off in the coal consumption by the lighting company and a like amount by the street railways company caused a large amount of screenings to be thrown on the market, which effectively lowered the prices of all screenings shipped from the mines in the vicinity. The railroads handling this coal and also the Terminal Railroad Association suffered a material loss by the reduction in the number of cars of coal handled per day.

Previous to receiving water power, the peak load in the Ashley Street plant was 55,000 kw., which required

a crew of 122 men for operation only, including coal and ash handling. The steam-generated peak this winter, in addition to the water power received, was 34,400 kw. The operating crew for this load and for emergency service in case the water power should fail and the station be required to pick up the entire load, is 87 men.

Through the increasing demand for energy the installation of new machinery in the Ashley Street station brought about many points that had to be worked out to meet the special conditions there. Among these were the condensers originally installed for the 5000-kw. units, which with their auxiliaries afterward served the 12,000-kw. turbines. The ratio of cooling surface to capacity on the old units was 4 to 1, while on the new installations it was reduced to 1.6. With the old condensers and the larger load there was a serious congestion in the upper bank of tubes. To relieve this congestion and trouble with packing leaks caused by the vibration of the tubes due to the high velocity of the steam, it was necessary to open up the top and center banks, taking out three rows of tubes in three places on both banks. This permitted the steam to be carried well down into the condenser and materially relieved the high velocities, giving a much closer balance in pressure between the top and bottom of the condenser and at the same time obviating all trouble in the packing at the tube ends.

A point worth mentioning in connection with the steam end of the 12,000-kw. turbines, was a weakness that developed in the third stage diaphragm nozzles. This, in Mr. Hunter's opinion, was brought about by the unequal expansion in the diaphragms, causing the thin nozzle plates to crack and in some cases to break out. This weakness was overcome by a change in the design, the nozzles being cast of brass in sectional plates. These plates, being portable, can be removed without dismantling the machine, although with the new design it was thought that it would never be necessary to remove the sections. Outside of this weakness the operation of these turbines has been most satisfactory, and the maintenance cost practically nil.

It would appear with the advance in the art and the higher capacities of machines being manufactured that the leaning is toward the horizontal machine. Some two years ago two 4000-kw. units were installed in the station and have given excellent satisfaction. The 20,000-kw. unit now being contemplated will be located in the space occupied by a vertical cross-compound reciprocating engine of 3000-kw. capacity, and as the demand for energy increases, 20,000-kw. units can be installed in the space now occupied by two other 3000-kw. reciprocating engines. This prime mover capacity, of course, will be governed by the space available in the station for additional boilers.

W. L. Abbott agreed with the preceding speakers that the boiler room was a very good place to start in order to reduce the cost of producing electrical energy. A boiler with its furnace he had frequently described as a piece of apparatus for the purpose of heating air and cooling it. The air is a medium for transferring heat from the fuel to the water in the boiler. Suppose a transfer of water was being made from one vessel to another and the cup with which the transfer was made each time was completely filled and emptied, there would be no loss. Filling the cup in one vessel, emptying two-thirds of it into the other and throwing the balance away would duplicate what is being done in the boiler room. Air is taken at a normal temperature, heated up to 2000 or 2500 deg., and cooled down to 500 or 600 deg. The rest of the heat is used to create a draft. That is, the air is driven up a smokestack, pulling fresh air after it through the fuel bed. To use 20 per cent of the heat of the fuel merely to push air through the fuel bed is a wasteful process. It is true that the temperature of the water in the boiler is some 400 deg. and cannot cool down the air. The remedy is to use economizers and cool down the furnace gases to the lowest point possible. Mr. Abbott would therefore abolish smokestacks for the purpose of creating draft. Boilers are being forced to 100 per cent overload every day with natural draft and with forced draft frequently from 300 to 400 per cent overload, and still the limit has not been reached. The speaker suggested that the boiler be cut in two, and half of it be forced to 500 per cent if necessary. The other half could be used as an economizer in two stages if need be and the gases cooled to the temperature of the feedwater. In this way there is a possible saving of 20 per cent.

Another medium for transferring energy is steam. It is loaded up with heat in the boiler and in the superheater and then in expanding it through the turbine the attempt is made to get back from the steam as much of that heat as is theoretically possible. Here is the place where practice fails. Conceive a sawmill steam plant with a leaky tea kettle of a boiler, the engine out of line and without any packing. Compare that with the modern high-pressure, low-vacuum turbine installation, and an approximate comparison between the thermal efficiency of the modern equipment and the actual amount of energy in the steam is obtained. To get from the steam as it goes through the turbine 20 per cent of its energy is doing very well. Four-fifths of it goes to the condenser. The only way to get a greater percentage of this heat is by raising the initial pressure and temperature of the steam as it enters the turbine and by reducing the final pressure and temperature of the steam as it leaves the turbine. Progress is being made slowly in the higher pressures and temperatures but the possible saving in this direction is small as a little increase in the temperature is accompanied by a considerable increase in pressure.

On the other end it is common to discharge the steam

into the condenser at a pressure one or two pounds above absolute. This looks to be inconsequential compared with 200 lb. initial pressure, but in this one or two pounds pressure which have been sacrificed at the lower end are 50 or 75 deg. of temperature, and this is a waste for which the engineering fraternity can make no apology. It appeared to the speaker that there had been less horse sense employed in the design of condensers than in any other part of the steam equipment. The manufacturers seem to think that a condenser is like a boiler and that its purpose is to cool off rather than to condense the steam and so it is passed up and down through a bank of thickly spaced tubes at a velocity almost equal to that of a high-powered bullet, for they seem to think that what is good practice in a boiler must be good practice in a condenser. The steam can only get through by piling up a back pressure.

To obtain greater economy in the engine room, make a condenser having the greatest possible area for the steam to strike the tubes, so that all of the cooling surface is immediately available for the steam when it enters the condenser. Instead of passing the steam through a long constricted passage full of baffles let it get at once in contact with the cooling surface at low velocity and be condensed without loss of pressure. A gain of 1½ in. of vacuum represents a possible increase of 25 per cent in the power from the turbine.

Two other suggestions were made for increasing the efficiency. The cost to put current on the bus bars does not consist alone of operating costs. It consists equally as much of the fixed charges on the cost of the powerhouse and equipment. Take the cost of operation of a plant, multiply it by two, and the cost of operation plus the fixed charges will be obtained. This more nearly represents the cost of the output. For a further reduction of this cost reduce the cost of the powerhouse. This is a bright idea that perhaps would not occur to the gentlemen designing powerhouses. In putting on some filagree and perhaps a steeple, they do not realize that they are loading up that powerhouse and that community with an increased cost on all the energy to be made in future years.

To get the lowest cost the equipment cannot be duplicated to guard against every conceivable contingency which may occur in this decade or the next. The size of the average powerhouse, and the amount of equipment in it should be reduced. With the usual power factor the apparatus on the average is busy about one-third of the time. About one-fourth of the apparatus is busy only 2 or 3 per cent of the time. In the course of the year, if the powerhouse is fully loaded at the time of maximum load, there is only 100 hours or 200 hours that the whole of the equipment is used. That last quarter of the equipment should not be installed but the peak load should be carried as an overload on the rest of the equipment. Then by reducing the cost of the powerhouse by one-quarter the cost of the output will be cut 12½ per cent.

NECROLOGY

M. L. JENKINS

M. L. Jenkins was born February 26, 1865, at Walworth, Wis. He received his education at Delavan, Wis., and served an apprenticeship as toolmaker with the Wilson Sewing Machine Company, Chicago, Ill. This experience was followed by brief periods as machinist with such companies as the Chicago Steam Engine Works, Chicago Die & Machine Works, A. H. Andrews & Company, and Wheeler & Tappan. In 1881 he was made foreman of the last named concern and two years later was promoted to superintendent, in which position he was in charge of all design. In 1891 Mr. Jenkins was made superintendent of the Gardner Steam Pump Company of Quincy, Ill., and in this connection designed and built a line of duplex steam pumps. In 1893 he became superintendent of Fairbanks Morse & Company, Beloit, Wis., where he engaged in the manufacture of gas and gasolene engines, steam pumps, hoisting engines and power transmitting machinery. He was for a time shop superintendent of Allis-Chalmers Company, Milwaukee, Wis., and in 1905 became associated with the Buda Company, Harvey, Ill., in the capacities of superintendent and general manager. His inventions and developments during this period covered miscellaneous gas engines for automobiles, commercial cars, and railroad motor cars, as well as miscellaneous types of operating mechanism used in connection with them, such as transmissions, etc., and the designing of original ideas as worked out by him in connection with tools for accuracy in production work and manufacturing. He died March 2, 1914.

ALBERT STEARNS

Albert Stearns was born in Rindge, N. H., December 20, 1833. When 21 years of age he was appointed to serve on the metropolitan police force in Brooklyn, N. Y., and six years later received the rank of sergeant. At the outbreak of the Civil War, he temporarily resigned this position to organize Company I of the 131st Regiment, New York Volunteers. He served with distinction throughout the war: while in Louisiana, as provost marshal and judge, also as sheriff, Department of the Gulf; and as military street commissioner in Savannah, Ga. His labors there were commended by Gen. William T. Sherman in his published report of May 9, 1865. He was slightly wounded at the battle of Cedar Creek and was brevetted a major for bravery in action. Major Stearns was the author of a book, Reminiscences of the Late War, which gives an entertaining account of the years spent in his country's service. At the conclusion of the war he was offered the rank of captain in the metropolitan police force, a position he retained until 1870. In that year he became connected with Church & Company, Syracuse, N. Y., manufacturers of bicarbonate of soda, and for 33 years served them as superintendent of factories and chemical works, as inventor of labor-saving devices and machines, and also as purchasing agent and confidential advisor. After the consolidation of Church & Company with the John Dwight Company, chemical manufacturers, Mr. Stearns became superintendent of the new concern, the Church & Dwight Company. This position he held for 17 years. He retired from active work in April, 1913, and returned to Brooklyn, N. Y. He died April 21, 1914.

MEETINGS

CINCINNATI, APRIL 23

A joint meeting of the Cincinnati Section and the Engineers Club of Cincinnati was held in that city on April 23, 1914. A. L. Jenkins read a paper on the Beginning and Development of the Machine Tool Industry in Cincinnati. The first large machine shop appears to have been that of Miles Greenwood, who came to this country from England. John Steptoe, also an Englishman, the first tool builder of Cincinnati, came there shortly after 1848. The paper was discussed by H. M. Lane, H. M. Norris, A. J. Baker.

A second paper, Reinforced Concrete, was read by Ludwig Eid, in which he traced the development of its use from its early beginnings in France. After a discussion of the properties desirable in the steel, cement, sand, and pebble or stone, the author devoted some time to consideration of local materials and to the proportion of the mix. An animated discussion followed. Owing to lack of time a third paper, Recent Developments in Smoke Abatement, by A. G. Hall, was omitted.

PROVIDENCE DINNER, APRIL 29

The annual joint meeting of the Providence Association of Mechanical Engineers with the Society took the usual form of a dinner, held in Providence on April 29. It was the largest in the history of the organization, being attended by over 250. After addresses by the President and Secretary of the Society, an interesting lecture on the Manufacture of Tubing was delivered by Harold T. Miller of the National Tube Company. This was illustrated by moving pictures representing the entire industrial process of tubing manufacture.

PHILADELPHIA, APRIL 30

A joint meeting of the Philadelphia Section of the Society and of the Franklin Institute was held on April 30. C. D. Young, Mem.Am.Soc.M.E., presented a paper on Locomotive Superheaters and Their Performance, which treated of the development of the superheater as applied to early locomotives and of its application to modern locomotives. The results obtained from exhaustive experiments at the Pennsylvania Railroad Company's testing plant at Altoona to determine the comparative economy of superheated and saturated steam were given, and also the results of operation on the road were analyzed as well. The paper was well illustrated with lantern slides.

QUARTERLY MEETING AT NEW HAVEN, MAY 1

The spring meeting of the New Haven Section was held in the Mason Laboratory, Sheffield Scientific School, New Haven, on the afternoon and evening of May 1, 1914, with Aeronautics and the Internal-Combustion Motor as the subject. The meetings were largely attended by local engineers, and a delegation of members of the Aero Club of America stopped off to attend the meeting on their way to Marblehead to participate in a demonstration of the Burgess-Dunne hydro-aeroplane.

E. S. Cooley tendered his resignation as chairman of the Committee on Meetings, which was regretfully accepted.

John J. Long of Brown University read an illustrated paper, A Review of Aeronautical Progress. The Proportions of Propellers and Engine Cylinders was discussed by David L. Gallup, and a paper on Fuels for Internal-Combustion Engines was presented by D. B. Pangburn. A letter was read from Everard Thompson of the Connecticut Aeroplane Company who was unable to attend the meeting. Joseph A. Steinmetz of Philadelphia spoke on Aircraft in War for Offense and Defense. A 100-h.p. Gnome aeronautical motor was on exhibition in the laboratory, having been loaned for the meeting by Edson F. Gallaudet of Norwich, Conn.

At six o'clock a dinner was served in the Yale dining hall to about fifty of the members.

The evening session convened about eight o'clock, with Prof. L. P. Breckenridge as chairman. James Hartness, President of the Society, made a few general remarks, and Calvin W. Rice, Secretary, spoke appreciatively of Mr. Cooley's work as chairman of the New Haven committee.

The Evolution and Status of Aeronautics was the subject of an illustrated paper by Henry Woodhouse, editor of Flying, and Howard Huntingdon of New York read an illustrated paper on Internal-Combustion Motors in the Field of Aviation. Mr. Steinmetz spoke informally on certain aspects of aviation and Edgar Beecher Bronson, author, explorer and aeronaut, told of some interesting experiences in Africa and South America.

ST. LOUIS, MAY 4

The St. Louis Section entertained the Associated Engineering Societies of St. Louis, on May 4, at the Hamilton Hotel. An illustrated lecture was given by Arthur Seubert, Through Germany with the A.S.M.E., which was followed by a general reception. Lantern slides made from photographs taken during the trip were used and Mr. Seubert, who attended the meeting in Germany, gave an interesting account. The occasion was made a Ladies' Night and proved a decided success.

SAN FRANCISCO, MAY 6

A meeting of the San Francisco Section was held in the Engineers Club on May 6. After a brief business meeting, a paper on the Stationary Diesel Engine was presented by Herbert Haas, in which he described the Diesel cycle, both two-stroke and four-stroke, and the standard types in both the horizontal and vertical engines. This was illustrated by lantern slides.

A. M. Hunt drew attention to what he considered the chief factor militating against the successful introduction of the Diesel engine in this country, namely the desire on the part of American designers to add improvements, instead of accepting European practice. Unsatisfactory operation was the result.

A. H. Babcock, consulting electrical engineer for the Southern Pacific Railway, followed, and cited two installations made by his company, where the trouble lay in the fact that stress was laid on the high economy in fuel consumption, without regard to the other features, including the cost of producing a horsepower. Upon placing a wattmeter in the electrical circuit it was determined that all the work done by the engine, rated at 100 h.p., could have been accomplished with 30 h.p. In conclusion, he paid a strong

tribute to the modern Diesel engine with special reference to its adaptability for marine purposes. A general discussion followed.

NEW YORK, MAY 12

The local section of the Society in New York was entertained at its monthly meeting on May 12 with a very interesting address by H. DeB. Parsons on the Main Drainage and Sewage Disposal Plans for the City of New York. Mr. Parsons is a member of the Metropolitan Sewerage Commission of the City of New York and has been closely identified with this important work of developing a plan that will be applicable to this great and rapidly growing district. He showed by lantern slides how remarkably the city and environs have grown in the past 10 or 20 years and gave statistics on the enormous increases of population, the development of the city boroughs and the consequently increased quantities of sewage to be disposed of. To provide adequately for both present and future needs, plans had to be prepared that should be practical, applicable to the conditions and elastic to permit of extensions, and Mr. Parsons showed how by division of the entire city into drainage districts, it is proposed to accomplish this in a practical manner. He referred to each district and outlined the adopted plans in considerable detail. His talk was also extended to the main drainage works of Boston, London, Dublin, Glasgow, Paris, Berlin and Hamburg, to show how the plans for this district may be extended and developed as future growth of the city may require. The talk attracted a great deal of interest in view of the unusual engineering problems that are entailed in some of the districts, particularly that embracing the lower part of Manhattan Island which involves a 7-mile tunnel under Brooklyn and lower New York Bay to an outlet on a proposed artificial island in the bay.

CHICAGO, MAY 13

The concluding meeting of the season of the Chicago Section took the form of a banquet and social meeting held on May 13, 1914, at the Sherman House, Chicago. Paul P. Bird, chairman of the section, presided and acted as toastmaster. The meeting was primarily for the purpose of discussing the subject of Machine Shop and Machine Tool Practice. An informal reception was given to James Hartness, President, and Calvin W. Rice, Secretary of the Society, who came on from New York to attend the meeting.

The subject of the evening was presented by P. W. Gates, Robert W. Hunt and Arthur M. Houser.

Election of officers for the ensuing year followed.

BOSTON, MAY 13

A meeting of the Society was held in Boston on May 13, Boiler Room Practice being the topic of the evening.

Captain Charles H. Manning opened the subject with a paper on the assigned topic, in which he related his own interesting experiences and the changes which had developed during his more than fifty years work among boilers and fire rooms. He was followed by George H. Diman, who had had a similar long experience in boiler room practice, and who said that he believed the best results were dependent upon the good spirit which could be aroused among the workers.

W. G. Diman spoke on modern Boiler Room Operation and I. E. Moultrop on the boiler room practice in large electric power stations, prophesying the early adoption of larger boiler units than at present used, with a much greater overload capacity than is now common. James D. Andrew spoke on simple and rugged boiler house and equipment design, and believed that automatic boiler feed was possible with a good degree of safety. He recommended the use of CO_2 recorders and of weighing devices and said that firemen should be given proper instruments to show conditions in the fireroom.

E. G. Bailey spoke on regulating the air supply and on the importance of a draft gage, and F. W. Dean of the effect of good and poor firing as shown by tests.

John A. Stevens emphasized the importance of the investment item and Henry Bartlett described the probable application of stokers to large locomotives, too large to be handled by hand by one fireman.

CINCINNATI, MAY 21

A joint meeting of the Cincinnati Section and of the Engineers Club was held in Cincinnati on May 21. Henry M. Waite, manager of the City of Dayton, gave an address on Municipal Government under the City Manager Plan, in which he stated that the organization of the Dayton city government was based on the plan that had proved successful with large corporations. Five commissions were elected by popular vote, and the city manager was chosen by these commissions. This manager in turn selected five heads of departments, known as directors, for the five divisions, law, finance, safety, service and welfare. Mr. Waite had made his appointments, he said, irrespective of political affiliations of the appointee, and subordinates were selected by civil service examinations. This form of government placed the responsibility of good government and efficient service upon the manager and his directors, and if he was dishonest and inefficient, the manager might be recalled and his directors dismissed. Mr. Waite illustrated the great saving possible under this plan, citing specific cases. About twelve cities were now following this plan, he stated.

There was an attendance of about 150 and many questions were asked and answered by the speaker, arousing much interest.

FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

An interesting example of what Sir Henry Bessemer called "cross-fertilization of sciences" is presented in this issue of the Engineering Survey: The formula for wind pressure on roofs is to be revised on the basis of data obtained in aeronautics.

THIS MONTH'S ARTICLES

Slessaryoff investigates the coefficient for the friction of a stream of gas discharging against the adjoining layers of air. In another article the efficiency and economy of jet apparatus, as compared with electrically driven pumps, for handling the circulation of water in a large heating plant is compared, the results being on the whole in favor of the jet apparatus. In the Machine Shop section is described an interesting device for keeping nuts on bolts, as well as a device for restoring the cylindrical shapes to deformed pieces.

Data on comparative tests of various materials used for impregnating mine timbers are also quoted. In the section on Mechanics will be found information on the use of jet apparatus as mixing machines, and on the conditions of self-rotation of plates immersed in a liquid, showing that in such a case the self-rotation depends on the moment of inertia of the system. Further, a new furnace for heat treatment of railway car-wheel tires is described.

In the section, Steam Engineering, will be found a statement concerning a process of determination of efficiency of blast-furnace boilers exclusively by means of analysis and temperature measurements of the heating gases and flue gases. The steam consumption of a rolling mill straight-flow steam engine is investigated, and its high economy shown. Ofterdinger describes his new system of feedwater preheating, designed particularly for use on steamers: water is preheated in two stages: in the first by exhaust steam from the auxiliary engines and low pressure receiver, and in the second by steam from the intermediate pressure receiver (triple or quadruple expansion engines). O. Dobbelstein, from data furnished by extensive tests made in Germany, discusses the application of surface combustion to boiler heating, and the improvements, partly made, partly projected, in this process in Germany. In addition to the use of gas, he speaks also of surface combustion firing with tar-oil as a fuel, and concludes that as yet it cannot be relied upon for continuous operation.

The problem of fuel saving through proper dimensioning of steam piping is discussed in the next abstract, and it is shown that the formulae used at present for the determination of pressure fall in various pipes and connections are utterly unreliable, and are apt to give too low results.

Mr. Freyn, in a paper before the American Institute of Mining Engineers, discussed the utilization of coke-oven and blast-furnace gas for power purposes, as well as a mixture of the two gases. The question of the use of reinforced concrete for docks, mainly with regard to the European practice, is the subject of the paper of Harrison S. Taft before the American Society of Civil Engineers, before which was also presented the paper of Guy B. Waite on Cinder Concrete Floors. J. L. Van Ornum, in a paper before the Association of Engineering Societies, establishes the effect of saturation on the strength of concrete, the rapid loss of strength on the first exposure and the slow and gradual recovery. Cast-Iron Wheel Records and Cleavage and Crystallization of Cast Iron are subjects of papers presented before the Canadian Railway Club.

The various articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Air Engineering

CONCERNING THE WIND PRESSURE ON ROOFS (*A propos de la pression du vent sur les toitures*, A. Sée. *Revue industrielle*, vol. 45, no. 2131-14, 1914, p. 186, April 4, 1914. 1 p., 2 figs. *pt*. From paper read before the Industrial Society of Northern France). Recent experiments in connection with aeronautics have raised a good deal of doubt as to the validity of the officially adopted formula for wind pressure against roofs and walls. It is usually assumed that the wind pressure on a surface with the plain normal to the direction of the wind is equal to the product of the area of the surface by the square of velocity times the coefficient 0.14. In the case of a roof it is assumed that the wind moves downwards at an angle of 10 deg. and strikes the roof at an angle $a + 10$ deg., where a is the angle of the roof with the horizon. Under these conditions the pressure is obtained by multiplying the preceding equation by $\sin^2 (a + 10)$. This official formula is, however, entirely antiquated and its lack of accuracy is obvious now that the coefficient of resistance of the air is known to be not 0.14, but 0.08. The hypothesis of the wind descending at an angle of 10 deg. is purely arbitrary. The law of sine square has been shown not to agree with experimental data, and finally the formula does not take into consideration the shape and location of the roof.

Experiments have been made recently at the Engineering Aeronautical Battalion of the Italian Army with models of two types of semi-lozenge shaped hangars (Fig. 1 A and B), where the pressure curve and the magnitudes of the pressures, at various points of the profile, are indicated. One sees at once that the pressure curve has nothing to do with either the sine square or simple sine law, or indeed with any law based on the angle of incidence. The wind pressures along the frontal surface of the structure rapidly diminish as the curve inflects, and become zero some time before the tip of the lozenge is reached; moreover, they become negative all along the rear surface, a fact which is not shown by the formula: There is therefore quite an important partial vacuum, independent of the curvature of the structure, and it appears that the wind pressure on each element depends not so much on the angle of incidence at that point as on

the location of that particular element with respect to the rest of the structure.

When, however, one comes to the consideration of the question as to which formula would be more acceptable than the old official formula, one finds that while this official formula is incorrect, any other formula which might be derived at the present time would be just as likely to be based on arbitrary assumptions and involve coefficients of doubtful value. Whether the new formula would give better results is somewhat doubtful, while it is a fact that structures built in accordance with the old formula proved to be quite stable. The author, therefore, rather curiously arrives at the conclusion that while the old formula is admittedly incorrect it should still be followed, at least until an absolutely good new formula can be derived.

Investigation of the Distance of Flow of a Fountain of Hot Air (*Izsledavaniye dalnaboynosti fontana teplava vozdookha,* V. Slessaryoff. *Journal of the Russian Metallurgical Society* (in Russian), no. 6, 1913, p. 709. 5 pp., 3 figs. *e*). In investigating analytically the problem of gas fountains one has to deal with a certain coefficient which takes care of the friction of the stream of gas against the

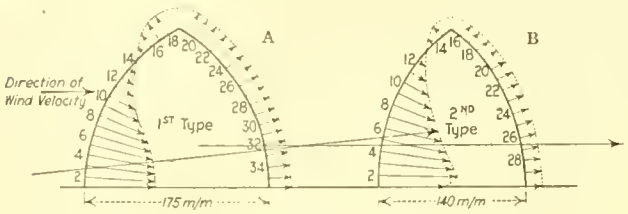


Fig. 1 Distribution of Wind Stresses on Buildings

adjoining layers of air. Practically no experiments have been made to determine it. The author investigated the action of a stream of air in a special apparatus described below and manipulated the results obtained in such manner as to determine the coefficient K in the equation of I. G. Yesman:

$$H = \frac{v^2}{2g} \cdot \frac{273 + t_a}{t_d - t_a} K$$

where H is the distance of flow of the fountain in meters, v initial velocity in meters, t_d temperature of the moving stream, t_a temperature of the surrounding stationary medium and K a coefficient.

In Fig. 2 A (outflow nozzle) H is height of flow of the fountain of warm air, H_o, height of flow of the fountain of unheated air. Normally to the direction of the stream is laid off the speed of the flow of air v; the solid curve represents the law of variation of velocity as a function of the distance of the heated stream having an initial temperature t_d; the dotted curve represents the law of variation of velocity of the unheated stream. The figure shows that the distance of flow of the heated stream is less than that of the unheated steam. If the magnitudes of the velocity and temperature be substituted in the equations, we shall obtain H larger than that obtained experimentally. We must therefore introduce into the equation a coefficient K which would satisfy the equation. The author found that the value of this coefficient is $K = 0.7$.

The experimental apparatus is shown in Fig. B. On a special support is placed a small electric motor, carrying on its shaft the drum of a small Sirocco blower with the outflow nozzle directed in such a way that the stream of air goes vertically downwards. The blower can deliver up to a velocity of 16 meters per second, this velocity being regulated within wide limits by means of a double rheostat placed on top of the supports. The air enters the blower through a bend with a little dome under which has been placed a kerosene lamp for heating the air; this lamp can be raised and lowered as desired by means of a movable support and screw. Two valves are placed in the tube for regulating the temperature of the air, one taking care of the warm air and the other of the cold air; by lowering the lamp and by manipulating the valves one could obtain practically any desired temperature for any given velocity of the outflow of air. At the beginning of the stream, the temperature would be measured by means of an ordinary thermometer located on the support, but the temperatures in the other parts of the stream have to be measured by a special thermometer which would be sensitive to rapid variations of the temperature of the air. Such a thermometer was made by the author in the shape of a conical vessel with walls of very thin copper (0.03 mm. or 0.001 in. thick), the inside of the cone being con-

TABLE 1 DISTANCE OF FLOW OF A FOUNTAIN OF HOT AIR

t_d Deg. Cent./Fahr.	H Meters Actual	H_1 Meters Calculated	$K = \frac{H}{H_1}$
60/140	1.08	1.58	0.683
75/167	0.835	1.18	0.707
85/185	0.745	1.015	0.730
			$K_{average} = 0.707$

$t_a = 15.5$ and $v_{max} = 2.2$

nected by a thin rubber pipe with an alcohol manometer. The air becomes heated in the vessel, expands and displaces the alcohol in the glass tube of the manometer; after the instruments have been properly calibrated, one can read the temperature from the manometer scale. In order to avoid the disturbing influence of barometric pressure, the internal space of the reservoir is placed from time to time into communication with the external air. Copper was selected as the material for this vessel owing to its high heat conductivity. The velocity of the flow of air was measured by an ordinary wing anemometer. The experiment was carried on in a large room with a temperature of the surrounding air of 15.5 deg. cent. (59.9 deg. fahr.), the room being so large that the blast of warm air practically did not affect the room temperature. The results of the investigation are presented in Table 1.

In the first column is given the initial temperature of the gas fountain, in the second the distance of flow of stream H, then H_1, the distance of flow of stream calculated from the Yesman equation (with coefficient unity), and in the last column values for the coefficient K. The initial velocity was all the time maintained constant and equal to 2.2 meters (7.2 ft.). The distance of flow of the stream of the fountain can be determined very exactly by means of the air thermometer described: even after the anemometer has stopped entirely, the thermometer would still indicate a flow of warm air. The coefficient K appears to vary somewhat with the initial tem-

perature, but for practical purposes its value may be accepted as 0.7.

Heating

THE WATER CIRCULATION SYSTEM IN THE HOT WATER CENTRAL HEATING PLANT OF THE COUNTY HOSPITAL AT KREMSIER (*Uber den Wasserumtrieb des Warmwasser-Fernheizwerkes der Landesheil- und Pflegeanstalt in Kremsier (Mähren)*, F. Heinl. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, no. 17, p. 658, April 25, 1914. 3 pp., 5 figs. *de*). The article describes the hot water central heating plant at the County Hospital in Kremsier, the interest of which lies in the fact that at first pumps were used for driving the hot water, but in 1912 they were replaced by a jet apparatus.

The boiler plant consists of one low-pressure hot water

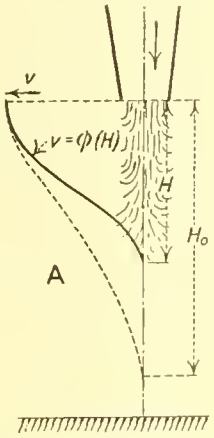
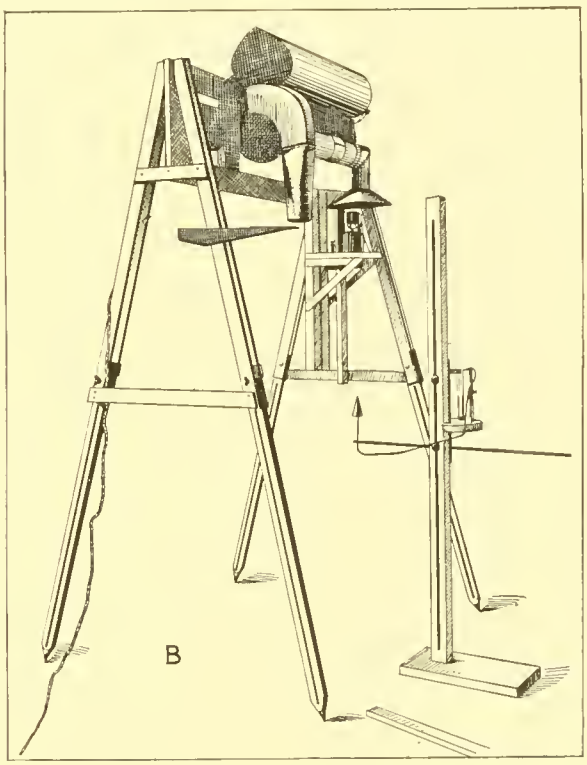


FIG. 2, A AND B FLOW OF A FOUNTAIN OF HOT AIR AND APPARATUS FOR MEASURING IT

boiler of 75 qm. (807 sq. ft.) heating surface and two high-pressure steam boilers of 140 qm. (1506 sq. ft.) heating surface, each working at a pressure of eight atmospheres absolute. Originally three centrifugal pumps, working either singularly or in parallel, were used to drive water through the hot water boiler into the direct piping. These pumps were driven by direct-current motors at 440 volts and 675 r.p.m. In the installation of the jet apparatus, the following points had to be considered: (*a*) the rise of temperature t-t_1 in the steam jet apparatus can be determined approximately from the equation $t\text{-}t_1 = a\sqrt{h}$, where h is the delivery head in meters of water (difference of pressure between the direct and return flow) and a is a constant which has a value of 4 to 5.5 when the amount of water is right; (*b*) when, with a delivery head remaining constant, the amount of water is decreased, the amount of steam used remains nearly equal, and is therefore approximately inversely proportional to the amount of water; (*c*) the amount of water ought not to fall below one-half to one-third of the maximum value. In the present case three jet apparatus have been installed having a diameter of 120 mm. (4.8 in.) for the water end and 80 mm. (3.2 in.) for the steam end, arranged in a manner such that they may be used either singularly or in parallel. Water in the jet apparatus is heated approximately 10 to 12 deg. cent. (18 to 21.6 deg. fahr.); for the measurement of the amount of water delivered a venturi nozzle, *M* (see Fig. A), is used.

Data of the tests of the plant with pumps are given in Table 2; temperature of water in the pumps during the tests was on the average of 64 deg. cent. (147.2 deg. fahr.) and in passing the hot water boiler was raised to 77 deg. cent. (170.6 deg. fahr.). The pumps were inserted first singularly, then in pairs and finally all three together in parallel. The readings were taken for the amount of water Q in cu. ft. per hr., pressure difference in front of the pump and behind the hot water boilers, and current i, the voltage being always 440 volts. From these were determined: the effective output $N_{eff} = \frac{Qh1000}{75.3600}$ e.h.p., the electric input $\frac{ei}{1000}$ k.w., or $N_{el} \frac{ei}{736}$ h.p., and overall efficiency of pump and motor $\eta = N \frac{N_{eff}}{N_{el}}$ It was found that on the average a single pump had an efficiency of about 15, two pumps 26 and three pumps 34.5 per cent. It appears therefore that the extraordinarily low efficiency of a single pump improves when two or more



pumps are placed in parallel, and with three pumps the efficiency becomes nearly double. The cause of this lies in the following: the pressure heads of a pump are not static but are used to overcome resistance and may therefore be expressed as $h = kv^2 = \beta Q^2$, where β depends on the piping; actually, from Table 2, it follows that β varies from 0.00057 to 0.00059, or, on the average, is 0.00058. Pressure heads and amounts of water, as long as the resistance in the piping is not changed, for example, by the shifting valves, give therefore parabolic curves. If, further, on the same diagram be plotted the characteristic curve of the pump, that is, the delivery curve for various delivery heads, at the points of intersection of the characteristic curve with the parabola, would be obtained the respective values for the pressure head and amount of water. Since one may assume that the pumps placed in parallel take part in the delivery at the same time, one obtains three points of the characteristic; for each pump, when h is equal to 2.3, 4.8 and 7.6 m., Q is equal to 63, 45.5 and 38 cu. m. per hour respectively. Thus

TABLE 2 DATA OF TESTS OF THE KREMSIER HOSPITAL HEATING PLANT. *A* PUMP CIRCULATION

No. of Test	Number of Pump	Water Circulated, per Hour, Cbm./Cu. Ft.	Pressure Difference h, M./Ft. of Water	$10^4\beta = 10^4 \frac{h}{Q^2}$	Effective Output, $\frac{1000\,Qh}{3600 \times 75}$ H.p.	Current i, Amp.	Electrical Input, $\frac{ei}{736}$ H.p.	Efficiency, $\eta = \frac{N_{eff}}{N_{el}}$ Per Cent.	Cost of Current E, Marks per Hour	For a Difference of Temperature between Direct and Return Flow of: 14 Deg. Cent.—25.2 Deg. Fahr.			25 Deg. Cent.—45 Deg. Fahr.		
										Heat Supplied per Hour, WE/B.t.u.	Cost of Coal K, Marks per Hour	$\frac{E}{K}$ Per Cent	Heat Supplied per Hour, WE/B.t.u.	Cost of Coal, K Marks per Hour	$\frac{E}{K}$ Per Cent
1	1	63/2224	2.3/7.54	5.80	0.54	5.75	3.43	15.6	0.60	882,000/3,501,540	3.56	16.9	1,575,000/6,252,750	6.37	9.5
2	2	63/2224	2.35/7.54	5.93	0.55	5.9	3.52	15.6	0.62	882,000/3,501,540	3.56	17.2	1,575,000/6,252,750	6.37	9.7
3	3	62/2188	2.25/7.23	5.85	0.52	6.5	3.88	13.3	0.68	868,000/3,445,960	3.51	19.3	1,550,000/5,973,500	6.27	10.8
4	1 and 2	90/3178	4.6/15.08	5.68	1.53	9.8	5.85	26.2	1.02	1,260,000/5,002,200	5.10	20.0	2,250,000/8,932,500	*10.91	11.2
5	1 and 3	90/3178	4.7/15.41	5.80	1.57	10.0	5.98	26.3	1.05	1,260,000/5,002,200	5.10	20.5	2,250,000/8,932,500	*10.91	11.5
6	2 and 3	94/3319	5.2/17.05	5.89	1.81	11.15	6.67	27.2	1.16	1,343,000/5,331,710	5.45	21.4	2,350,000/9,329,500	*10.95	12.2
7	1, 2, and 3	115/4060	7.65/25.08	5.80	3.26	15.8	9.15	34.5	1.65	1,610,000/6,391,700	6.51	25.4	2,875,000/11,413,750	11.61	14.2

* The original has 0.91, 0.95 respectively.

over the first characteristic plotted may be the efficiency curve. From the above it follows that the cause of the low efficiency of pumps running singly lies in the fact that their resistant head is too small while the delivery head must have to be designed large in order that the pump should not stall when placed in parallel. This could be obviated only by using for small amounts of water a small pump with a small delivery head, and for large amounts a large pump with a large delivery head, but even then the efficiency would not exceed 25 to 30 per cent.

The jet apparatus have given results shown in Table 3. The value of $\beta = \frac{h}{Q^2}$, which represents the resistance in the piping, is on the average equal to 0.00056, that is, less than in the pump plant. The noise in the apparatus is very small and hardly noticeable even at a small distance. The system has been at work since January 1913 and has given complete satisfaction. As compared with the pump system, the jet system has the following advantages: the expense for the electric current, which amounts to about 15 per cent of the coal bill, is eliminated owing to the absence of moveable parts. The working of the system is extremely simple and reliable. The installation and maintenance cost of the jet apparatus is lower than in the case of pumps and electric motors. Since the circulation does not require power, the main pipes may be made of considerably smaller diameter, which means lower cost of installation and insulation of the pipes as well as lower losses through radiation, owing to decreased surface of the pipes. The use of the jet apparatus is, however, limited by the fact that it requires high pressure boilers. They work as efficiently as hot water boilers, but must have an installation of their own, and therefore jet apparatus for heating purpose can be efficiently applied only in large plants.

Machine Shop

Nut Locks (*Les freins d'écrous*, L. Letombe. *Mémoires de la Société des Ingénieurs Civils de France*, ser. 7, vol. 67, no. 2, p. 219, 8 pp., 11 figs. *d*). The Cheneau nut lock consists of a steel wire bent spirally arranged in a way such as to tighten with a certain initial tension over the thread both of the bolt and the nut. The upper and lower ends of the wire are bent at right angles towards the bolt; the end of the wire coming from the uppermost spiral is long enough to pass into a hole previously drilled in the nut. The nut, therefore, carries with it the wire brake during the screwing as shown in Fig. 3. Since the resistance of the wire to friction when passing over the thread of the bolt

TABLE 3 DATA OF TESTS OF THE KREMSIER HOSPITAL HEATING PLANT. *B* JET APPARATUS

No. of Test	Jet Apparatus No.	Steam Pressure, Atmospheres Gage	Amount of Water per Hour, Cbm./Cu. Ft.	Pressure Difference h, M./Ft. of Water	$10^4\beta = 10^4 \frac{h}{Q^2}$	$N_{eff} = \frac{1000\,Qh}{3600 \times 75}$ H.p.	Temperature in Front and Behind the Jet Apparatus, Deg. Cent./Deg. Fahr. t_1	t	$t - t_1$ Deg. Cent./Fahr.	$\alpha = \frac{t - t_1}{\sqrt{h}}$	Position of Regulating Needle
8	1	5.6	81/2860	3.6/11.8	5.50	1.20	47.5/117.5	57.5/135.5	10/18	5.26	slightly throttled
9	1	5.3	94/3319	4.7/15.4	5.32	1.64	48/118.4	60/140	12/21.6	5.53	wide open
10	1	5.5	56/1976	1.8/5.8	5.76	0.37	48/118.4	58/136.4	10/18	7.47	throttled
11	2	5.4	97/3425	5.0/16.4	5.31	1.80	48/118.4	61/141.8	13/23.4	5.81	wide open
12	2	5.6	80/2825	3.5/11.5	5.47	1.04	48/118.4	59/138.2	11/19.8	5.89	throttled
13	3	5.2	95/3355	4.7/15.4	5.22	1.65	48/118.4	60.5/140.9	12.5/22.5	5.77	wide open
14	3	5.5	80/2825	3.4/11.2	5.32	1.01	48/118.4	59.5/139.1	11.5/20.7	6.25	throttled
15	2 and 3	4.8	172/6073	too small	....	....	48.5/119.3	63/145.4	14.5/26.1	....	....
16	2 and 3	4.9	142/5013	to be read	....	....	50/122	64/147.2	14/25.2	....	throttled

results in loosening the spirals of the wire, there is no trouble in tightening the nut, but if at any time it should be desirable to turn the nut the other way, the spiral, in tightening, provides such an effective braking that it is necessary to break the wire before it can be loosened. Therefore, when it is desired to loosen the nut, the wire must first be turned loose, which may be done simply, as shown in Fig. E. All that is necessary to permit use of the Cheneau brake is to drill a hole in the nut, and in order to do that a special templet, shown in Fig. F, may be used.

Universal Rectifier (*Rectificateur universel. Omnia,* vol. 9, no. 431-14, p. 210, April 4, 1914. 1 fig. *d*). The universal rectifier was designed to restore the cylindrical shape of any piece deformed by usage owing to its having been made in two parts. It may be used practically in any case and is based on the principle of continuity. The piece rectified is held between the two jaws of the apparatus and these are brought closer together by means of screws shown in the drawing. One jaw has a roller *E* (Fig. 4) and another a knife edge *F*. When the distance between the jaws is considered to be sufficient, the rectifier is turned round by the handles *D*, somewhat like a capstan, and in a few minutes the piece is made perfectly cylindrical.

Materials

Comparative Tests of Processes for Impregnating Mine Timber (*Vergleichsversuche mit Imprägnierungsverfahren für Grubenholz,* O. Dobbelstein. *Glückauf,* vol. 50, no. 16, p. 611, April 18, 1914. 7 pp., 11 figs. *e*. Cp. Jahresbericht des Vereines für die bergbaulichen Interessen im Oberbergamtsbezirk Dortmund für 1913, Essen 1914, p. 162). By request of mine owners, the council of the Association of Mining Interests in the Dortmund mining section, in 1912, made some comparative tests of various methods of wood impregnation in common use, to determine among other things in how far impregnation of mine timber is economical. The circular inquiry elicited data which showed that notwithstanding the increased application of iron and reinforced concrete for mine structures in the Ruhr coal region, wood impregnation was still of considerable importance. For the tests pine wood was used of dimensions to suit the available impregnating tank, 1.9 to 1.5 m. (74 to 59 in.) long and 15 to 16 cm. (5.9 to 6.2 in.) in diameter. The article describes in detail the experimental arrangement and apparatus used.

The tests were made with the following materials: the basilit process, in which a salt is used consisting of 88 parts of sodium fluoride and 12 parts of dinitrophenolanilin (a 1.67 per cent solution, 2 deg. Bé. and a temperature of 11 deg. cent. (or 51.8 deg. fahr.). The next test was made with a process in which a 2.4 per cent solution of oxymercurichlorphenolsodium and sodium sulphate, commercially known as Bayer salt. Next tests were made on impregnation with mercury silicate consisting of a mixture of 1 kg. sublimate, 76 kg. of water glass, 0.71 kg. of ammonia and 1 cu. meter of water. A special salt known in trade as Glückauf was also used consisting mainly of nitrated phenols, as well as tests with the well-known Rüping process of tar-oil impregnation; also, with a substance known as mykantin, consisting of 24 per cent dinitrophenol salts, 36 per cent ligninsulphate salts and 40 per cent water and impurities. The article gives detailed data and costs with reference to German conditions. The impregnated pieces were sent into four different mines, each mine receiving at least one piece from each process tested and arrangements have been made for the determination of temperature and moisture as well as for gas analysis at stated intervals.

In a year's time the testing committee will inspect all the test pieces and make a report on the condition of the pieces, and will establish the inflammability of the timbers, ignition

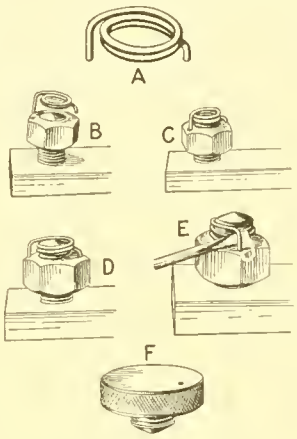


Fig. 3 Cheneau Nut Lock

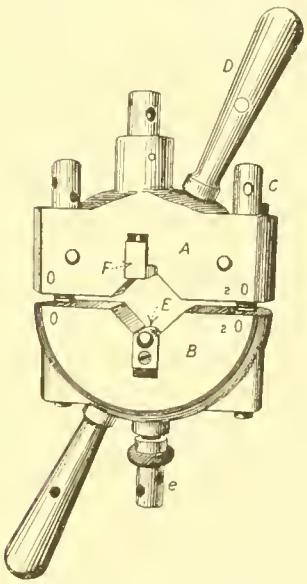


Fig. 4 Universal Rectifier

point and time taken until full combustion starts. Five years from the beginning of the test the timbers will be sent to a testing laboratory and there tested for mechanical strength and inflammability.

Mechanics

Concerning the Use of Jet Apparatus as Mixing Machines (*Zur Verwendung der Strahlapparate als Mischmaschinen,* Oskar Nagel. *Chimiker-Zeitung,* vol. 38, no. 48, p. 513, April 21, 1914. *p*). Jet apparatus have recently been rather widely used for delivery of liquids and gases. Their great advantage consists, of course, in the fact that they have practically no moving parts, and therefore permit easy and safe handling, as well as that they are free from breakage. On the other hand the mechanical efficiency of such

apparatus is very low on account of the fact that nearly 75 per cent of the energy of the jet issuing from the nozzle is lost in the eddies created in front of the second nozzle, from which gas or liquid delivery is coming. This amount of energy is consumed in mixing the active fluid with the fluid delivered. This large loss does not matter so much where the jet apparatus is used only intermittently, that is say for a few hours a day or a week. Nevertheless, it appears that it is primarily not a delivery apparatus at all, but a mixing device. In the present article, the author suggests its use as such, especially in connection with the chamber process of producing sulphuric acid, where at present the chambers have to be large to permit of intimately mixing the gases.

This difficulty can be overcome with the steam jet apparatus, and the arrangement which the author suggests consists in having all the gas pass through several jets, to be delivered into the chamber by means of a steam jet apparatus which would produce a very intimate mixture between the gas and the steam. In order to make the eddy action of the apparatus as thorough as possible, he advises that before the gas enters the apparatus the pressure be reduced to below atmospheric pressure. With this arrangement the highest efficiency of the mixing process may be obtained, 1 kg of steam at 2 atmospheres pressure delivering through the nozzle 20 cbm. of gas, and since considerably less steam is thus required for the jet apparatus than for the formation of sulphuric acid, additional steam may be introduced into the chamber either by means of a second large jet apparatus, in which case it would produce an increase of draft, or by injecting a certain amount of water directly into the chamber. The author points out also that an atomizing nozzle may be used to a certain extent as a mixing nozzle or as an absorption apparatus, but when an atomizing nozzle is used for this purpose, it should be enclosed in an appropriate casing arranged in such a manner that every gas particle be compelled to pass through the liquid enclosure.

A Hydrodynamic Experiment (*Expériencé d'idrodynamique*, D. Riabouchinsky. *Il Bollettino dell'Aero Club di Roma*, vol. 9, no. 1, March 1914, p. 7. 1 p., 2 figs. *e*). The author has previously found that a rectangular plate immersed in water cannot be given a movement of self rotation while the same plate will rotate with great energy in air. This difference could not be ascribed to the influence of viscosity since in his experiments he dealt with currents of water and air, the respective velocities of which were proportional to the kinematic viscosities of these two fluids. The next supposition was that this phenomenon depended on the moment of inertia of the plate. In accordance with the method of variables of zero dimension, we have here

$$\frac{nr}{v} = f\left(\frac{c}{\rho r^2}\right)$$

where n is the number of revolutions of the plate in a unit of time, r one of its linear dimensions, c moment of inertia of the plate, ρ density of the surrounding medium, v velocity of the current and f a function which is to be determined. It appeared theoretically probable, however, that even should the moment of inertia of the plate be increased in proportion to the density of the surrounding medium, the plate would remain quite stable and normal to the direction of the current, and it is only with considerable effort (while using high velocities of flow) that one could succeed in forcing the plate to abandon this position, to which, however, it would rapidly return.

In order to test experimentally this assumption, the author constructed the apparatus shown in Fig. 5 A. A rectangular sheet plate *a* (0.3 x 0.075 m., 11.8 in. x 2.95 in.) has an axis *b* which rotates with very little friction in a ball-collar thrust-bearing *c* while the moment of inertia of the entire system may be varied by shifting the lead cylinders *dd*. Experience has shown that vanes of this kind immersed in a current of water could be easily given a movement of self rotation and that the rotation of the plate was the more uniform, the greater the moment of inertia of the system. If the moment of inertia of the system is not large, the eye can distinguish in the motion of the plate a noticeable angular acceleration every time the plane of the vane in running before the current passes into the third quadrant (Fig. B). The *minimum* moment of inertia at which the motion of self rotation begins, without becoming stable, may be approximately estimated as being equal to twice the moment of inertia of a circular cylinder of water having a length equal to the length of the plate and a basis with a

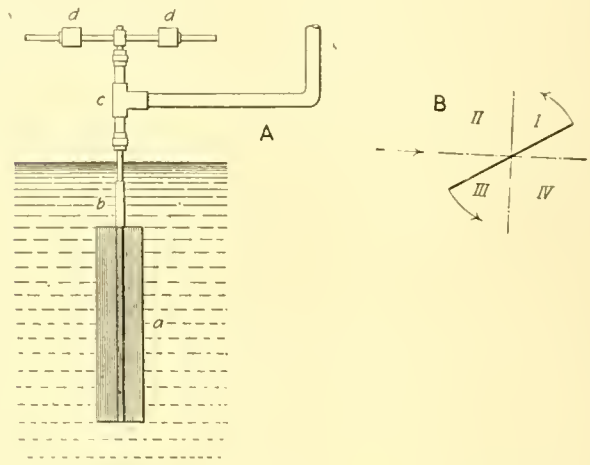


Fig. 5 Apparatus for Establishing Conditions of Self-Rotation of a Plate Immersed in a Liquid

diameter equal to the width of the plate. In order that a plate should turn continuously, the moment of inertia of the system must be equal to at least five times the moment of inertia of such a cylinder.

Railway Shops

New Furnace for Systematic Heat Treatment of Tires (*Novaya metodichskaya pech dla termicheskoy abrabotki bandajey*, B. Grum-Grzimaylo. *Journal of the Russian Metallurgical Society* (in Russian), no. 6, 1913, p. 706, *d*). The furnace for mass production of tires must satisfy the following requirements: (*a*) Each tire must be equally heated all along its circumference. (*b*) All tires in one batch must be heated equally at an equal rate and must remain in the heated state the same length of time. (*c*) When the required temperature has been reached, arrangement must be made for the tire to be taken out easily and rapidly so as to undergo the operations required by its treatment and the cooling required.

The furnace described in the present article is said to be able to satisfy all these requirements. The tires laid one over the other are placed on the platform of a crane which acts also as the bottom of the furnace (inverted flame). The gases are produced in a special furnace and travel as shown by the arrows, passing gradually downwards and encircling

the column of tires both inside and outside. The uppermost tire is heated up to the required temperature (registered by a thermometer), while the lower tires are being prepared. When the uppermost tire becomes hot enough, it is taken out through a window made in the wall of the shaft at the level of this tire. At the same time a new cold tire is introduced into the furnace, which is done in a very simple manner. Owing to the convenient form of the tire and presence of the flange, the entire column can be easily clamped side-wise by three clamps and held suspended while the bottom of the furnace is lowered by a crane. A new tire, Fig. B, is placed on the bottom, which is then raised, the clamps removed and the entire set of tires raised up by the height of one tire. In this position the upper tire will take the place of one which has just been removed, while the latter is treated as required. If full heat treatment with annealing is required, a second furnace may be installed for the annealing part but this furnace does not have to be heated at all. On the contrary cold air will be admitted from below, will cool the lowest tire, gradually rise upwards, and escape through the opening in the dome, provided by a throttle regulating the rate of cooling of the tires. The tire which is to be cooled will be placed

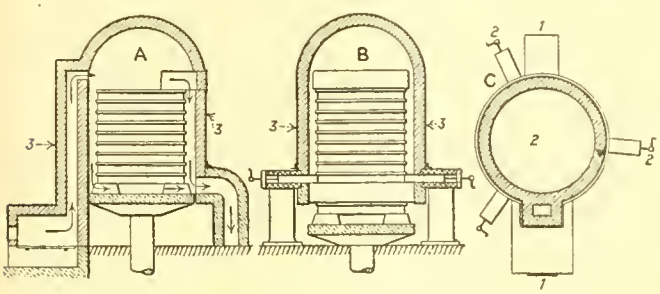


Fig. 6 Continuous Furnace for Heat Treatment of Tires

in the second furnace on top and will be removed from below by means of clamps and a crane. This furnace provides for a systematic, absolutely uniform heating of tires at the rate equal for all tires and also permits of measuring conveniently the temperature of the heated tire. In this way it permits a continuous mass production of tires, heated and treated in an absolutely uniform manner.

Steam Engineering

Concerning the Determination of Efficiency of Blast-Furnace Gas Boilers (*Zur Ermittlung des Wirkungsgrades von Hochofengas-Dampfkesseln. Stahl und Eisen,* vol. 34, no. 16, p. 674, April 16, 1914. 3 pp., 2 figs. *p*). The heat consumption of a blast-furnace gas boiler is composed of the following three parts: (*a*) Heat usefully consumed, that is, transferred to the water evaporated (efficiency). (*b*) Loss of heat through the flue plus heat carried off in unburned gas particles. (*c*) Loss through radiation and conduction. Other losses which occur in steam boilers, such as losses through soot and grate residues, do not exist in blast-furnace gas heating.

This makes possible a method of determination of the boiler efficiency exclusively by means of analysis and temperature measurement of the heating gases and flue gases. Of the three parts into which the heat consumption of a blast-furnace gas heated boiler is divided, the loss through radiation and conduction is comparatively small and subject to variations only within narrow limits. Of course, no general statement can be made as to its magnitude, which depends in particular cases on the size and construction of the boiler and efficiency of the insulation, but usually it varies between 2 and 10 per cent at normal loads. As a rule one may estimate that in a watertube or firetube boiler, the absolute value of the loss through radiation and conduction varies proportionally to the load, but its relative value changes within narrower limits and perhaps even remains constant; at any rate the value of this source of loss may be determined for each boiler system once and for all by proper tests.

The author believes that even when the load is variable, the loss through radiation and conduction may be estimated correctly to within 2 or 3 per cent, which is entirely satisfactory for carrying out the determination of boiler efficiency in accordance with the present method. The losses through flue gases and incomplete combustion may be very easily determined from knowledge of the temperature and chemical composition of the blast-furnace gas and flue gas, whereupon by knowing the specific heats and heats of combustion of each particular gas, may be determined the losses through free and latent heat of the flue gas referred to one cubic meter of the heating gas. The heating value of the latter is known from the analysis of the blast-furnace gas, and the boiler efficiency appears therefore as the difference between the heating value of the blast-furnace gas on one side, and combined losses through flue gas, radiation and conduction on the other side.

An objection might be raised that the determination of the flue gas losses is uncertain in view of the uncertainty of the data concerning the specific heats of the gases; this however is not quite so. While the values of specific heats of gases may still be considered doubtful at very high temperatures, their values at low temperatures such as occur in the flue of a steam boiler may be considered to be fairly well established (the author gives the table of specific heats of two-atomic gases, water and carbondioxide referred to grammolecule, as determined by Langen, Pier, and Holborn and Henning), the maximum error being between 0.04 and 0.06 of the heating value of the blast-furnace gas. One must not forget also that direct determination of boiler efficiency, when superheated steam is used, is based on the specific heat of steam which also cannot be considered to be fully established.

In order to test the applicability of this process under various conditions, the author considers the following contingencies: (*a*) The amount of gas, its heating value and ratio of gas to air remain constant. (*b*) The amount of gas varies as shown in Fig. 7 A, while the ratio of gas to air during each single phase of load variation remains constant. The same applies to the heating value of gas. (*c*) The amount of gas and ratio of air to gas vary all the time.

Case (*a*) happens only when a certain boiler construction or a certain kind of gas is investigated and the plant is run so as not to be affected by outside influences. In such a case it is sufficient to take one test of the heating gas and flue gas and make one temperature determination for each of them at any time. In case (*b*) the efficiency is determined for each particular phase of load variation as in case (*a*) and the average efficiency is determined in accordance with the formula

$$\eta_m = \frac{h_1 q_1 t_1 \eta_1 + h_2 q_2 t_2 \eta_2 + h_3 q_3 t_3 \eta_3 + \dots}{h_1 q_1 t_1 + h_2 q_2 t_2 + h_3 q_3 t_3 + \dots}$$

For the determination of η_m it is therefore necessary to know the amount of gas consumed in each phase. The ad-

vantage, as compared with the direct method of determination, is therefore quite important, since in this process are required not the absolute values but the ratio of the single velocities or single amounts of gas consumed in different phases, and even large errors in the determination of the relative velocity will have only a slight influence on the precision of results. The taking of tests and measurement of temperature may be made at any time during the single phase of load variation, but, of course, only after the plant has come into the normal state of operation, say 1 or 2 minutes after the variation of the amount of gas admitted. Only in the case when the heating value of the gas varies, the taking of tests should be made during the entire duration of the phase. Instead of determining separate gas amounts and efficiencies, and calculating from them the average efficiency, one may also take a continuous sample of blast-furnace gases and flue gases during the entire duration of the experiment and determine the average efficiency from this continuous sampling. In order to make the composition of the test sam-

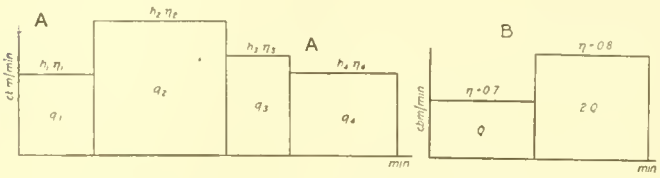


Fig. 7 Phases of Load Variation on Blast Furnace Gas Boilers

ples correspond absolutely to the average composition of the blast-furnace gas or flue gas, it would be necessary to vary the suction velocity at which the test sample is taken in proportion to the respective velocity of the gases. Actually, however, it is sufficient to vary the suction velocity of the gas samples only in proportion to the velocity of the blast-furnace gas.

Case (*c*) comes into consideration when the gas pressure varies considerably. The determination of the average efficiency is then carried out, as in the preceding case by continuous suction of test samples of the blast furnace and flue gases.

In order to determine how far the average efficiency as calculated depends on the possible errors in the determination of the relative gas values, the following example is numerically carried through; the gas admission takes place in two phases of load variation in accordance with Fig. 7 B. The average efficiency is therefore

$$\eta_m = \frac{Q_x 0.7 + 2Q_x 0.8}{3Q} = 0.767$$

If the velocity of the flue gas in the first phase of load variation has been measured 10 per cent too small and if the second phase 10 per cent too large, the average efficiency will be found to be

$$\eta_m = \frac{0.9Q_x 0.7 + 2.2Q_x 0.8}{3.1Q} = 0.776$$

only 0.4 per cent too high.

Steam Consumption of a Rolling Mill Straight-Flow Steam Engine (*Dampfverbrauch einer Walzenzug-Gleichstrom-Dampfmaschine*, H. Ortmann. *Stahl und Eisen*, vol. 34, no. 17, p. 709, April 23, 1914. 2 pp., 2 figs. *e*). The article describes some tests on steam consumption of a straight-flow steam engine used to drive a three high rolling mill. As the work of the mill increased, the engines used to drive were at the time found to be too weak, until finally a large straight-flow steam engine of the most modern design was installed of 1700 mm. bore, 1400 mm. stroke and 100 to 130 r.p.m. This engine is provided with a quiet running automatic valve gear and an independent and very sensitive governing. The speed of rotation remains pretty constant even during rolling and after very large overloads or falls of load it is very rapidly brought to the normal level. The regulation of the engine takes place far more rapidly than was the case with the tandem engine, which is, of course, a result of the simpler construction of the single cylinder engine. The speed, as a rule, is 100 r.p.m., but when small shapes are rolled it may be raised to 130 r.p.m. The boiler pressure with the present boiler is eight atmospheres, but it is proposed to raise it to 12 atmospheres, with corresponding changes in the cylinder. The steam consumption was guaranteed by the manufacturers at 5.2 kg. (11.44 lb.) per i.h.p-hr. at seven atmospheres gage pressure at the engine and 300 deg. cent. (540 deg. fahr.) superheat. The steam consumption at various loads does not vary much. As determined from the diagrams, the steam consumption appears to be as follows:

	Steam Consumption per H.P-Hr.	
At I.H.P.	Kg.	Lb.
2700	5.3	11.66
4000	5.2	11.44
5300	5.45	11.99
6650	6.1	13.42
8000	7.3	16.06

These favorable figures led to a belief that, considering the former steam consumption of 9.5 kg., the new engine would pay for itself in a short time. After the engine had been in operation for about six months it was decided to determine its actual steam consumption, and to do this a brake test was undertaken, with the engine working for three hours at an average rate of output of 3000 h.p. This test was followed by a second test with a load of 1820 h.p. on the engine, which was required in order to establish how consumption varies with variations of load. Every 5 minutes during the tests diagrams were taken. Condenser losses between engine and boiler were taken into consideration in determination of the steam consumption. The condenser plant, located near the engine, is driven by electric motors and consists of centrifugal pumps for handling the water of condensation and an electrically driven air pump. The power consumption of the condenser plant was continuously measured by a recording wattmeter and was found to be 115 h.p. Table 4 gives the test data; since the data obtained during the test referred to a given steam pressure and temperature of superheat, they had to be recalculated in order to find the values of steam consumption for guaranteed conditions.

TABLE 4 DATA OF TESTS OF A STRAIGHT-FLOW STEAM ENGINE DRIVING A ROLLING MILL

	Test 1	Test 2
Average speed, r.p.m.	97.8	102 0
Length of test, hours	3	1 5
Average pressure at the engine, atmospheres gage	6 3	7 03
Steam temperature, deg. cent./fahr.	283/541 4	289 9/553.8
Vacuum, per cent	87.5	89 9
Average output, i.h.p. (continental)*	2982	1822
Steam consumption, as measured, without condensation, in kg./lb. per i.h.p-hr.	5 83/12 82	4 6/10.12
Steam consumption reduced to 7 atmospheres gage pressure, 300 deg. cent. (540 deg. fahr.) superheat, 90 per cent vacuum, without condensation, in kg./lb. per h.p-hr.	5 3 11 66	4.5/9.9
Power consumption of the condenser plant, per cent	3 9	6.3

* A continental horsepower is equal to 736/746 American horsepower.

High Feedwater Preheating on Steamers (*Hohe Speisewassercorwärmung auf Dampfern,* Otterdinger. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, no. 16, p. 617, April 18, 1914. 5 pp., 2 figs. *deA*). The author presents a new method of preheating boiler feedwater particularly adapted to use on steamers. He proposes to preheat the water by exhaust steam from auxiliary engines and receiver steam to a temperature of 140 deg. cent. (284 deg. fahr.) and higher. The advantage of such high preheating of feedwater lies first in the improvement of the efficiency of the engine plant, and second in the beneficial action on the life of the boiler, which is in this way spared from the heavy stresses consequent upon the injection of comparatively cold water. In addition, the higher the temperature of the water the freer it is from air, which is objectionable when present in the boiler. For such high preheating of the feedwater two-stage preheaters in series are used, working on steam of different pressures. When such preheaters are used in connection with triple or quadruple expansion engines, they may first be heated by the exhaust steam from the auxiliary engines with an addition of steam from the low pressure receiver. From this preheater the water passes into the second element, where it is heated by the steam from the intermediate pressure receiver, the pressure of the steam in the second element being maintained at a higher level than in the first preheater, i.e., at about the same level as the pressure in the intermediate pressure receiver. Fig. 8 shows the arrangement of such two-stage preheaters, where the entire set is inserted into the pressure piping of the feed pump, although the first preheating stage might also be inserted into the suction piping of the pump. In general, however, it would appear to be advisable to make both preheating elements of equal size and construction and to place them on to the pressure piping, providing them with means for air and oil separation. To regulate the pressure of the heating steam in the second stage, a throttling valve is provided so arranged that the water of condensation of the heating steam, but not the steam itself, is allowed to pass. In order to avoid heat losses the entire water of condensation from the heating steam must pass into the suction piping of the feed pump or the tank of the air pump. If the feed pump is of the plunger piston type it is advisable to lead the water of condensation from the heating steam of the second preheater stage not directly to the suction side of the feed pump but into the heating steam space of the first preheater stage, in order that it should give up there as much as possible of its heat before it reaches the feed pump together with the rest of the water of condensation from the first preheater stage. In this way the feedwater at the suction end of the pump remains comparatively cool notwithstanding the high degree of preheating on the pressure side of the pump, which is of importance for the good working of the feed pump.

The following tests were made to show the advantages derived from higher superheating of feedwater by two-stage preheater arrangement involving the use of steam from an intermediate pressure receiver. The boiler was provided with artificial draft (Howden process) and Schmidt superheaters and had the following dimensions: heating service of boiler in contact with water, 396 qm.; grate area, 95 qm. (1021 sq. ft.); heating service of superheater in contact with steam, 182 qm. (1959 sq. ft.); and steam pressure 13.5 atmospheres. The main engine was a triple expansion vertical marine engine with surface condensation and pumps driven by connecting beams and had the following dimensions: stroke, 1050 mm. (41.3 in.); diameter of high-pressure cylinder, 600 mm. or 23.6 in.; intermediate cylinder, 970 mm. (38.1 in.); and low-pressure cylinder 1575 mm. (61.8 in.). The two-stage feedwater preheater was inserted into the pressure piping of the feed pump, the heating area in either stage being 7.5 qm. (80.7 sq. ft.), thus making a total of 15 qm. (161.4 sq. ft.)

Two tests have been made. In test A the plant was run with preheating of feedwater by exhaust steam from the auxiliary engines and receiver steam from the low-pressure receiver in the first stage and by intermediate pressure receiver steam in the second stage. In test B, the plant was run in the same manner as in test A, but the heating steam from the intermediate pressure receiver was cut off and only the first stage of the preheater was working (in the same manner as in test A). The degree of admission in the steam

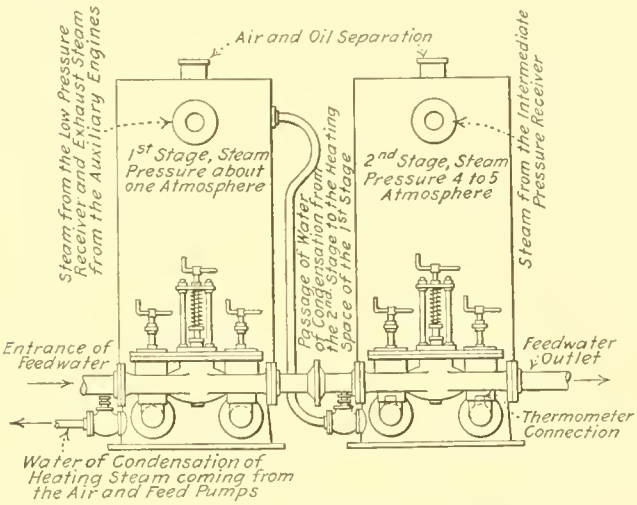


Fig. 8 Two-Stage Feedwater Preheater

cylinder was the same in both cases. The data obtained in the tests are shown in Table 5, while Table 6 gives the comparison of the data of the two tests recalculated. The feedwater in the first test was heated to 126 deg. cent. (258.8 deg. fahr.) and in test B to 79 deg. cent. (174.2 deg. fahr.). No measurement of coal consumption was made, but the water returned by the feed pumps to the boiler was measured by a water meter of the Kegler type. The heat consumption calculated from these values gives a more reliable basis for the estimation of the operating conditions present than would be possible to make from the measurement of coal consumption. During the tests A and B no auxiliary feedwater was admitted. The heat consumption figures per indicated horsepower-hour given in Table 6 seem to be too good, but, for the purpose of comparison between the two, this does not matter. Heat losses which occur during the test may be assumed to be distributed evenly over the entire duration of the tests. During both tests the ventilation machinery, steering gear engine, and ash-hoist were driven by steam, the ventilation constantly, steering gear as necessary, and the ash-hoist to lift from 22 to 24 buckets at each test; the weather was good, the sea nearly quiet and the steering gear engine only little used. The author reports also control data obtained from an investigation of indicator

diagrams taken during the same tests. Both methods indicated a heat saving of from 3 to 4.2 per cent when the temperature of feedwater is maintained at from 126 to 136.5 deg. cent. (258.8 to 277.7 deg. fahr.). The cause of the heat saving lies in the high latent heat of steam. The steam from the intermediate pressure receiver proceeds to do further work in the intermediate and low-pressure cylinders

TABLE 5 DATA OF TESTS OF FEEDWATER PREHEATING, ONE AND TWO STAGE

	Test A	Test B
Duration of test, hours	3	3
Admission, per cent		
High-pressure cylinder	62	62
Intermediate cylinder	37	37
Low-pressure cylinder	42	42
Steam pressure, atmospheres		
Boiler	13.8	13.7
High-pressure receiver	13.1	13.0
Intermediate pressure receiver	5.65	6.05
Low-pressure receiver	1.69	1.70
Condenser	0.15	0.15
Steam temperatures, deg. cent./fahr.		
Superheater	285/545	295/563
High-pressure receiver	268/514.4	278/532.4
Intermediate pressure receiver	214/417.2	222/431.6
Low-pressure receiver	113/235.4	115/239
Water temperatures, deg. cent./fahr.		
Suction piping of feed pumps	43/109.4	48/118.4
Pressure piping of feed pump, first preheater stage	67/152.6	76/168.8
Pressure piping of feed pump, second preheater stage	126/258.8	79/174.2
Suction piping of circulation pump (sea water)	11/51.8	10/50
Pressure piping of circulation pump at exit from condenser	50/122	51/123.8
Air temperature in the machine room, deg. cent./fahr	28/82.4	30/86
Boiler draft in the air duct at the fan, mm. of water	30	30
Engine output in indicated h.p.		
High-pressure cylinder	430	371
Intermediate cylinder	395	443
Low-pressure cylinder	440	444
Total	1265	1258
Speed, r.p.m.	74.3	74.4
Ship speed as measured by log, knots	10.7	10.8
Quantity of water, as indicated by meter, liters/gal.	20620/5493	18870/4983
Quantity of feedwater, kg./h.	19362/42596	18332/40330
Specific weight of water at 126 or 79 deg. cent. respectively	0.939	0.972

TABLE 6 RECALCULATED DATA OF TABLE COMPARED

	Test A	Test B
Boiler pressure, atmospheres	13.8	13.7
Steam temperature in superheater, deg. cent./fahr.	285/545	295/563
Average engine output, i.h.p.	1265	1258
Steam consumption		
Total, kg./lb.	19362/42596	18332/40330
per h.p-hr.	5.102/11.22	4.86/10.69
Heat generation, WE/B.t.u.		
of steam coming from the superheater	721.3/2863.5	726.6/2884.6
of feedwater from the boiler	126/490.2	79/313.6
Heat supplied to working fluid in boiler and superheater, WE/B.t.u.		
(a) per kg./lb. of feedwater	595.3/1071.5	647.6/1165.6
(b) per i.h.p-hr.	3037/5466.6	3147/5664.6
Saving in heat in test A as compared with test B, per cent	3.5	

of the engine (having regard to the heat which reaches a boiler with the feedwater) at thermal efficiency of about 12 per cent, while the steam which is taken from the intermediate pressure valve casing and used for the higher preheating of the feedwater is returned to the boiler with the utilization of at least 90 per cent of its heat. This difference in the efficiency of utilization of part of the steam accounts for the better saving of heat with the two-stage preheater.

Surface Combustion for Boiler Heating (*Die flammenlose Oberflächenverbrennung zur Kesselbeheizung,* O. Dobbelstein. *Glückauf,* vol. 50, no. 14, p. 525, April 4, 1914, 11 pp., 10 figs. *de*). This article is based on the work of the German commission on coke ovens, which, in connection with the Dortmund Association for the Inspection of Boilers, has carried out a series of tests on surface combustion boilers at which the inventors, Prof. W. Bone and R. Schnabel, were represented. The tests are prefaced by a brief description of the surface combustion boiler and improvements which the German manufacturers are proposing to make in them. One of such improvements is the construction of a more condensed type of machine containing in itself a preheater and superheater, the latter being heated by a mixture of air and gas, burned in a loosely thrown fireproof mass as shown in Figs. 9 A and B, the gases of combustion combining with the boiler flue gases and passing out through the preheater *v*. Instead of sensitive gas cocks pipes of a cross-section practically equal to those of the fire tubes are used which the gas enters laterally, and the air from the rear. Not the gas admission but that of the air of combustion is regulated by means of ring valves set in the rear part of the tubes. The gases come through the main pipe *z* and divide in front of the boiler through four horizontally placed side by side branches with small cross-section. These branch pipes pass between the extension of the fire tubes and supply with gas each one of the two fire tubes. The lowest branch pipe is an exception, however, since only the second lowest row of fire tubes (see Fig. C) is connected with it. The lower five fire tubes, *aa*, have no supply of gas and air mixture, but are heated by exhaust gas coming through pipe a_2 from the separately heated superheater. In addition there are provided a smaller number of fire tubes, probably about 60, having a larger cross-section and being about 3 m. long. This arrangement is provided for the case when hot feedwater is already available. On the Hanover mine the boiler is heated by coke-oven gas having a heating value of about 4000 WE (7600 B.t.u.), previously passed through the benzol separating plant, but not freed from hydrogen sulphide nor cyanogen. After about three weeks of operation it was found that the fire clay filling in the front end pipes, on account of the high temperature prevailing, was partly melted and partly broken up. It was also found that the output of the boiler, which was initially about 60 kg./qm. of heating surface, had decreased considerably because the porous mass in the fire tubes of the preheater became clogged up, partly through deposits and partly owing to sulphurous formations, so that the exhaust notwithstanding a larger consumption of power could not supply a sufficient amount of gas and air mixture. This led to renewal of the porous mass both in the fire tubes of the boiler and those of the preheater after which the first real series of tests had been started. Several of these tests quoted in the article may be considered only as preliminary, since during the performance adjustments of the gas cocks and even alterations in the arrangements were made. The results of tests during some of the days were remarkable: The first day, during an 8-hour test, an output of 61.7 kg./qm. of the fire tube surface was obtained with considerable variation of the gas pressure at the beginning of the test. The next day when this inconvenience was eliminated, the output rose to 66 kg./qm. The efficiency of the boiler was 93.3 per cent and that of the preheater 3.9 per cent. If one takes the steam consumption of the elec-

trically driven exhaust fan, including all losses, as 10 kg. per h.p-hr., the total efficiency, including the preheater, would be about 89 per cent with a moisture in the steam of about 2.5 per cent average. These outputs would represent an important advance if they could be maintained for regular operation, which, the article states, is not yet possible. After 14 days' run the residues in the fire tubes of the preheater, owing to the clogging of the porous mass, had already increased to such an extent that the boiler had to be shut down in order to clean the fire tubes. It is now intended to take out the filling from the tubes of the preheater entirely and then establish the fall of efficiency. After several months of operation, the tests will be repeated in order to establish whether a further fall of efficiency occurs owing to the decomposition of the fire clay filling in the fire tubes of the boiler. After three months of operation the boiler and preheater have been opened in order to see if there was any scale formation and to take out the fire clay from the fire tubes. It was found that during this run of the boiler, estimated at about three months, in the front end of the fire tubes in the boiler a thin, hard layer of scale was formed, which in the rear ends of the pipes reached a thickness of 4 to 5 mm. The copper pipes of the preheater were strongly attacked so that they had to be replaced by new pipes. The attacking of the pipes was due to the fact that when the gases of combustion were cooled down in the preheater to about 90 to 110 deg. cent. (194 to 230 deg. fahr.), the sulphurous acid had an opportunity to unite with water and thus form sulphuric acid, which naturally strongly attacked the copper of the pipes. The analysis has shown that in the mass taken out from the pipes there was 57 per cent copper sulphate and 10 per cent iron sulphate. Therefore the cooling down of the gases of combustion to the temperatures of 90 to 110 deg. cent. (194 to 230 deg. fahr.) is to be rejected for operating considerations, especially as the gain in heat is only from 2 to 3 per cent, while the loss through the increased power combustion of the exhaust practically reduces to nothing whatever is gained by reduction of the temperature to so low a level. The copper pipes have been replaced by cast-iron pipes, which was done especially because the use of the more expensive material did not appear to secure any corresponding advantage. The fire tubes of the boiler were filled with new fire clay mass and new tests made. It must be borne in mind, however, that the gas pressure could not be maintained at the same level as in the second test, and as a result both the gas combustion and boiler output were about 5 per cent below that of the former test. With coke-oven gas firing in this type of boilers with numerous fire tubes in regular operation, one cannot hope to obtain more than 60 kg. of steam per hour per 1 qm. of the heating surface, since the available gas pressure is not usually more than 100 mm. (4 in.) of water. Whether special apparatus to increase the gas pressure would prove to be economical or advisable remains as yet to be seen.

Here, as in all systems of gas firings, it is important to maintain as uniform a gas pressure as possible, since only in this case the admission of air can be maintained so as to have the combustion preceded by the slightest possible excess of air. In this connection the fireproof filling of the pipes may be improved, even supposing that as it stands it could withstand operation for a length of time at the high temperature used. Owing to the irregular form of the separate pieces it is extremely difficult to make the filling so that the resistance in all of the pipes shall be equal. The Berlin-Anhalt Machine Company is therefore working on the preparation of a special uniform filling made up of pieces of refractory material of the same size. This will make it possible to place filling in such a manner as to maintain the resistance practically uniform in all the pipes, while the total resistance will be materially reduced, and this will lead to a reduction in the power consumption of the exhaustor and raise the efficiency of the plant. These tests have further shown that for ordinary metallurgical practice the construction of the boiler with numerous fire tubes is not suitable since they require quite a large amount of attendance. The above mentioned concern is therefore endeavoring to reduce the number of tubes in their new boilers, and it is considered possible that later on ordinary fire tube boilers can be converted into surface combustion boilers. This would materially increase their output, and further, the conversion of a fire tube boiler into a surface combustion boiler would eliminate the objection made to the Bone boiler in that its water space is too small and that it has too low a reserve of steam.

The tests described also included tests on the application of tar oil in surface combustion boilers, for which purpose the experimental boiler shown in Figs. D and E has been used. It was designed to work at 12 atmospheres gage pressure and had a diameter of 1.3 m., and a length of 1.7 m., provided with 37 fire tubes of 76.5 mm. inside diameter, thus constituting a total heating surface of 12 qm. Immediately connected with the boiler there is a preheater, *c*, also enclosing fire tubes and supplemented by a second preheater, *d*, of the same construction, the installation of which was required because a single preheater utilized the heat of the flue gas sufficiently; in front of the firebox and partly inside it has been placed a combustion chamber, *a*, lined with refractory material and connected with the firebox of the boiler by means of slots in its refractory jacket. Over the boiler is located a wooden shed, on the roof of which is placed the tar oil supply tank from which the oil flows automatically into the boiler after being preheated by exhaust steam to about 90 deg. cent. (194 deg. fahr.), to distribute itself into three nozzles, *b*, set in the front wall of the combustion chamber. The electrically driven fan provides the air of combustion, the pressure of which is sufficient to atomize the tar oil and to overcome the resistance of the fire tubes.

Previous to each test the boiler was maintained in operation for about 2 hours, this time being sufficient, on account of the small content and consequent rapid heating, to bring the boiler into its normal state of operation. The tar oil and feedwater were weighed, the feedwater being also checked by means of a Siemens water meter; the readings of pressure, temperature and power consumption at the fan were taken at regular intervals of 15 minutes, the gas analysis being as far as possible taken also at the same intervals. On the whole the tests have shown that on forced runs with surface combustion boilers and tar oil as fuel, outputs up to 120 kg. per hour can be obtained. It is doubtful, however, that the boiler can be relied on to run regularly at such a rate of output, since both after the first and after the third tests it was found that the front tube wall leaked, even though it appeared that the fire clay wall built in front of it would protect it from the immediate action of the fire. On the other hand, it must be remembered that the cooling of

the boiler was very rapid because after the end of the test the oil firing was cut off immediately. It appears therefore that this type of boiler is not suitable for continuous operation when there are many rolled-in connections in the zone of the highest temperatures. The Berlin-Anhalt Machine Company has therefore designed a different type of boiler in which the tar oil comes in through a single nozzle together with the air of combustion supplied by a special fan. The combustion chamber consists of a single cylinder of refractory material, placed in the fire tube. The hot gases enter through the fire clay grating into the third part of the fire tube which is filled with large pieces of fire clay. It is expected that this type will be more suitable for continuous operation than the one shown in Figs. D and E.

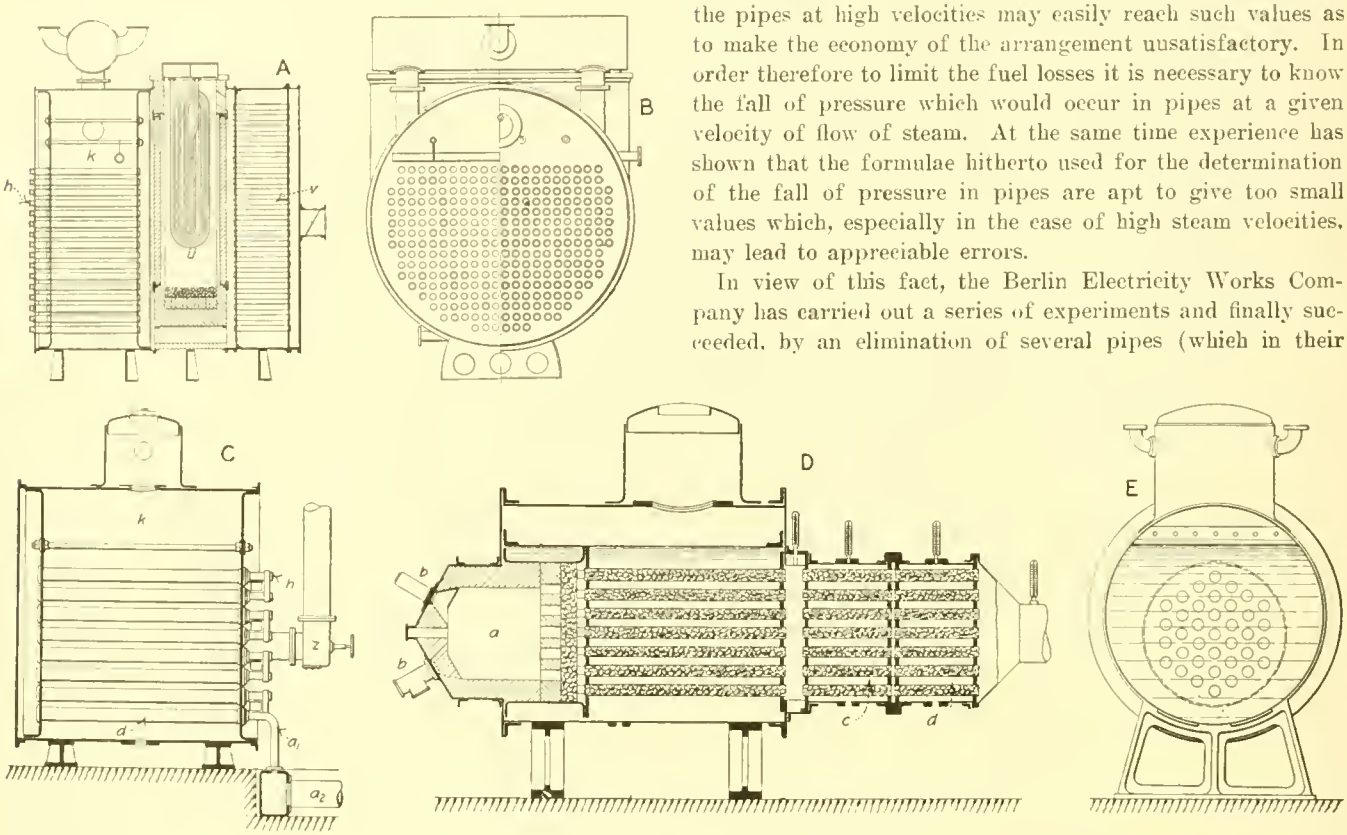


Fig. 9 German Surface Combustion Boilers

The author concluded that neither the coke-oven gas fired boiler nor that using tar oil was suitable for continuous operation, though it was possible that a different design would obviate the present difficulties.

Fuel Saving Through Proper Dimensioning of Steam Piping. Investigations on Pressure Fall of Flowing Steam (*Brennstoffersparnisse durch richtige Bemessung der Dampfleitungen. Untersuchungen über den Spannungsabfall des strömenden Dampfes*, M. Guilleaume. *Feuerungstechnik*, vol. 11, no. 14 and following; article not finished. *ex*). Eberle in *Forschungsarbeiten des Vereines deutscher Ingenieure*, vol. 78, has shown that when superheated steam of about 330 deg. cent. (626 deg. fahr.) is flowing heat losses in pipes protected by insulation amount to approximately 1500 calories per qm. (252 B.t.u. per sq. ft.) of the external surface of the pipe. It is therefore of great importance to reduce these losses as much as possible. He has further shown that this constant loss is inversely proportional to the amount of steam flowing through the pipe. It is therefore in the interest of a better utilization of fuel to use as high steam velocities in the pipes as possible, but the intermittent drawing off of steam in the case of reciprocating engines makes it impossible, on account of consideration of safety, to use steam velocities in excess of 25 to 30 m. (82 to 98 ft.). The practically uniform drawing off of steam in most of the turbine systems permits of leaving out of consideration the question of safety, but too high velocities cannot be used there either, owing to the fact that the loss of pressure in the pipes at high velocities may easily reach such values as to make the economy of the arrangement unsatisfactory. In order therefore to limit the fuel losses it is necessary to know the fall of pressure which would occur in pipes at a given velocity of flow of steam. At the same time experience has shown that the formulae hitherto used for the determination of the fall of pressure in pipes are apt to give too small values which, especially in the case of high steam velocities, may lead to appreciable errors.

In view of this fact, the Berlin Electricity Works Company has carried out a series of experiments and finally succeeded, by an elimination of several pipes (which in their time have been put in for the very purpose of reducing the fall of pressure in the system) to obtain a saving in fuel of several thousand marks per year. This was done by taking out certain branches in the piping system which offered an especially high resistance to the flow of steam, substituting for them other pipes of lower resistance. The steam velocity after these alterations could be increased to nearly double its former value and at the same time the fall of pressure was maintained within such limits as would not affect the full utilization of the machinery.

The determination of the fall of pressure in pipes conducting saturated or superheated steam is usually done by means of the following formulae: For straight pipes without bends or valves or other area reducing elements, formula 1 is used:

$$p_1 - p_2 = \beta_1 . \gamma . w . \frac{l}{d} \quad \ldots\ldots\ldots\ldots [1]$$

where p_1 is the steam pressure at the entrance into the piping and p_2 at the exit from the piping, both in kg./qcm., l is the length of the piping in meters, d inside diameter of the

piping in meters, γ average specific weight of the steam, w average velocity of steam in meters per second and β_1 coefficient of resistance or conductance for smooth pipes. While Guthermuth has determined the value of this coefficient as 15×10^{-8}, Eberle has found that its value is 10.5×10^{-8}. A still different value is that given by Fritzsche, who found that β_1 varies with the diameter of the pipe d and the product $w\gamma$, as follows:

$$\beta_1 = \frac{9.4}{10^5 (\gamma w)^{0.148} d^{0.269}} \quad \ldots\ldots\ldots\ldots [2]$$

and the value obtained by Eberle, corresponds fairly well to that derived from this equation for a pipe with a diameter of 70 mm. (2.8 in.) and $w\gamma = 50$. An experiment of Eberle with the piping of 70 mm. (2.8 in.) in diameter has established the fact that in the case of poppet valves, slide valves, shut-off corks, the resistance of these elements is equal, under similar conditions, to that of a pipe of the same diameter and 16.4 m. (53.8 ft) long. As regards equalization pipes and compensation bends, data of tests of C. Bach and R. Stückle[1] with two pipes, 55 and 100 mm. (2.2 and 4 in.) inside diameter have been published, but whether the coefficient of resistance determined for this case would apply to bends of other diameters or radii of curvature remains to be proved.

In how far all these formulae can be relied on for the determination of the pressure fall in the piping may be seen from the following example: A certain piping system consisted of two parts, namely, one piece 300 mm. (12 in.) inside diameter and 40 m. (131 ft.) long and a second piece joined to it 350 mm. (14 in.) inside diameter and 55 m. (180 ft.) long. Into the first were built in a standard steam stop valve of 300 mm. (12 in.) diameter and a lyra equalization bend with a radius of curvature of 1.2 m. (3.93 ft.) two arcs of 90 deg. and radius of curvature 0.9 m. (2.95 ft.). In the second piece were built in two standard steam stop valves of the same diameter as the pipe, two arcs of 90 deg. and 1 m. (3.28 ft.) radius of curvature. The calculation made in accordance with the above formulae gave, for a steam velocity of 30 m. (98.4 ft.) per second, an average specific weight of steam of 4.8, a pressure fall of 0.168 kg./qcm. (2.38 lb. per sq. in.), while direct measurement under the same conditions has given an actual fall of pressure of 0.59 kg./qcm. (8.38 lb. per sq. in.). When the steam velocity was raised to 55 m. (180 ft.), the pressure fall observed was 2 kg./qcm. (28.4 lb. per sq. in.), while that determined from the formulae 0.56 (7.96 lb. per sq. in.), which shows plainly how little reliable the above formulae are.

The article describes the experimental arrangement used in these tests. The measurement of fall of pressure was made in mm. of mercury by means of a special manometer, and, since the errors of observation are inversely proportional to the pressure differences measured, the experiments were carried out with as high steam velocities as possible. The temperature of water and of the mercury column was taken into consideration whenever the heat radiation might have affected the reading of the manometer. It was found, however, that the points at which measurements were made had to be selected in straight sections of pipe, since when it was attempted to measure the pressure fall inside a valve, the eddies there led to the indicated pressure fall being about 40 to 50 per cent lower. The points of measurement were therefore always selected at about 200 mm. (8 in.) from the flange joint. The velocity of steam was established by meas-

No	Length	Ins Dia
1	750	300
2	7850	300
3	7500	300
4	10,000	300
5	10,400	300

No	Length	Ins. Dia
6	800	300
7	7500	300
8	4750	300
9	5850	300
10	750	300

No	Length	Ins Dia
11	3125	300
12	800	300
13	3500	275
14	700	275

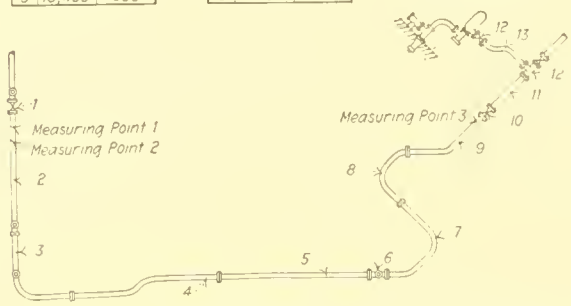


Fig. 10 Diagram of a Steam Piping System showing Points of Measurement of Pressure Fall

TABLE 7 DETERMINATION OF PRESSURE FALL IN STEAM PIPING

No. of Test	Duration of Tests, Min.	Average Pressure in Piping, Atmospheres Absolute	Average Temperature in Piping, Deg. Cent.	v, Average Volume of 1 Kg. (2.2 Lb.) of Steam in Cbm. (1 Cbm. =35.-314 Cu. Ft.)	$\gamma = \frac{1}{v}$	Steam, in Kg. per Hour	w, Velocity of Flow of Steam per Sec., in Piping 300 Mm. (12 in.) in Diameter, in M. (1 M. =3.28 Ft.)	Pressure Fall in the Piping, $p_1 - p_2$, Atmospheres	l, Length of Piping in M. (1 M. =3.28 Ft.)	$w.\gamma$	Coefficient of Resistance $\beta_1 = \frac{p_1 - p_2}{w^2 \gamma} \frac{l}{d}$
1	60	13.63	352 0	0 212	4 72	56887	47.35	0.1784	54.25	223.4	9.32×10^{-10}
2	60	12.42	353.0	0.233	4 29	52035	47.65	0.1587	54 25	204 6	9.02×10^{-10}
3	60	11.35	345.5	0.253	3.96	48111	47.73	0.1461	54.25	189.0	$8 95 \times 10^{-10}$
4	60	10.20	345.8	0.282	3.55	43055	47.69	0.1368	54.25	169.2	8.39×10^{-10}
5	60	9.29	351.9	0.313	3 20	39200	48.13	0.1205	54.25	154 0	$8 99 \times 10^{-10}$
6	60	8.18	338 4	0.348	2.88	35028	47.84	0.1076	54.25	137.7	9.03×10^{-10}
7	60	6.16	338.8	0.463	2.16	26571	48.33	0.0829	53.00	104.3	9.30×10^{-10}
8	60	7.17	340.2	0.399	2.51	30938	48.45	0.0927	53.00	121.6	8.91×10^{-10}
9	60	8.17	346.0	0.352	2.85	34842	48.14	0.1054	53.00	137.0	9.05×10^{-10}
10	60	8.18	348.0	0.353	2.83	34847	48.37	0.1066	53.00	126.9	9.15×10^{-10}
11	60	9.18	342 6	0.311	3 22	38850	47.47	0.1220	53.00	152.6	9.54×10^{-10}

[1] For an abstract of the article of C. Bach and R. Stückle, see *The Journal*, August, 1913, p. 1444, and *The Engineering Review* (London) April 15, 1914, p. 375.

uring the water of condensation coming from a steam turbine which appeared to be a more exact method than determination by measurement of boiler feedwater in which a source of error is constituted by the determination of the boiler water level. The tests extended to the determination of the fall of pressure in straight pipes, quarter bends and expansion pipes, poppet valves, slide valves and in T-pipes as well as in combinations frequently occurring in actual practice, such, for example, as the piping leading from the upper drum to the main steam piping or from the entrance into the water separator to the nozzles of a turbine.

The piping of 300 mm. (12 in.) inside diameter was first investigated. The data of this test are given in Table 7. Fig. 10 indicates schematically the construction of the piping, all quarter bends being transferred into the horizontal plane. The variation of the specific weight of the steam was effected by means of the throttling valve I. In order to make sure that the throttling did not affect the pressure measurement at point I, a second point of measurement has been established 1450 mm. (57 in.) from the middle of the flange joint. Tests 7 to 11 refer to the stretch from measuring point II to measuring point III. Measuring point III is located 200 mm. (8 in.) in front of the flange joint, at the valve X. The length of the piping from measuring point I to measuring point III is 54.25 m. (178 ft.) and from measuring point II to measuring point III 53.0 m. (174 ft.). Into the stretch measured are built in seven flange joints (steel castings with the pipes rolled in), one T-piece VI, serving as a joint for another pipe and during these tests passed through by the steam without change of direction, and nine quarter bends of different radii and length. The absolute pressure was determined by means of a check spring manometer at point III, the fall of pressure in the stretch measured by a mercury manometer described elsewhere. The average pressure in the piping was determined by these two observations. In column 12 of Table 7 the coefficient of conductance β_e was calculated from the formulae. [The article is not finished.]

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

Bulletin, No. 88, April 1914, New York.

Sound Ingots, Sir Robert Hadfield

Notes on the Plastic Deformation of Steel during Overstrain, Henry M. Howe and Arthur G. Levy

Manganese Steel, with Especial Reference to the Relation of Physical Properties to Microstructure and Critical Ranges, W. S. Potter

Notes on the Utilization of Coke-Oven and Blast-Furnace Gas for Power Purposes, Heinrich J. Freyn (abstracted)

NOTES ON THE UTILIZATION OF COKE-OVEN AND BLAST-FURNACE GAS FOR POWER PURPOSES, Heinrich J. Freyn (30 pp., *cd*). The paper attempts to cover the whole field of utilization of coke-oven gas for power purpose, as well as the surplus gases of a blast furnace. The author distinguishes for the coke-oven gas between the "cost of production" and "value of consumption" of the gas and finds that the intrinsic value of both blast-furnace and coke-oven gas depends greatly on the use factor of the power plant, and at a price of say 12 cents per 1000 cu. ft. for domestic use coke-oven gas would be more valuable as a gas engine fuel if the power plant operates at 80 per cent load factor throughout the year. When there is an unlimited market for electric power and nearly full output of the gas engine station, it would be more profitable to operate gas engines on coke-oven gas than to sell the latter for domestic purposes, provided coke-oven gas could be used in very large gas engine units as satisfactorily as blast-furnace gas, which is as yet not quite the case. Coke-oven gas varies greatly in composition according to the kind of coal carbonized and the time of generation during the process of carbonization, and contains from 50 to 60 per cent hydrogen. Blast-furnace gas requires approximately its own volume of air, while coke-oven gas must be mixed with from 8 to 15 volumes of air for complete combustion. The large percentage of hydrogen causes an extremely rapid flame propagation, making a combustion of a more explosive character than is the case with blast-furnace gas. The compression in coke-oven gas engines must, therefore, be kept lower than is customary for blast-furnace gas engines. But according to thermodynamic law, a lower compression is necessarily followed by a lower thermal efficiency. But it has been found in practice in Germany that the actual heat consumption per b.h.p-hr. of coke-oven gas engines at full load is practically the same as that of blast-furnace gas engines for the same load conditions, which is due mainly to the fact that, for practical considerations, coke-oven gas engines must be operated on very lean gas mixtures. Owing to the snappy action of the gas, coke-oven gas engines are at times quite susceptible to back-firing and premature explosions, and effective cooling of gas cylinders, pistons, piston roads, etc., becomes therefore a very important matter. This, as will be stated later, is apt to lead to troubles of its own. The latest coke-oven gas engines built by Thyssen & Company were installed in Westphalia. Each engine is of the twin-tandem, double-acting four-cycle type, having four gas cylinders 47½ in. in diameter, 51 in. stroke, and develops at 94 r.p.m. about 5000 b.h.p. It is used to drive alternators operated in parallel with a central station in Essen, the parallel operations being beyond criticism. The compression pressure is only 85 lb. and the maximum explosion pressure does not exceed 250 lb. per sq. in. The M. A. N. Company of Nuremberg, Germany, say that they are building units of 6000 b.h.p. capacity in four cylinders. Generally, however, it seems that in Europe about 1100 to 1200 b.h.p. per double-acting gas cylinder is at present the upper limit while in this country the majority of gas engine manufacturers restrict the capacity of coke-oven gas engines to about 700 to 850 b.h.p. per double-acting cylinder.

As regards the fuel it is the presence of sulphur in coke-oven gas in the form of sulphuretted hydrogen and carbon bisulphide which causes all serious trouble. The slightest water leak into the gas cylinder from defective pistons or water-cooled exhaust valves results in serious corrosion of all finished parts, particularly of piston rings, piston roads and metallic packing. This corrosion is caused by sulphuric acid formed by the combination of oxygen and water with sulphur dioxide resulting from the combustion of sulphur in the gas. Several gas engine builders in Germany abandoned on this account the use of water-cooled exhaust valves and substituted solid non-cooled valves. But many prominent manufacturers prefer to use water-cooled Durana metal exhaust valves on account of the high temperature of the exhaust gases. In recent years considerable progress has been made in designing sulphur cleaning plants which eliminate nearly all of the sulphuretted hydrogen but no practicable means

have so far been discovered to separate carbon bisulphide from the gas. Nitric acid formed in the gas cylinders during combustion of the charge has also a corroding effect upon the finished engine parts. This source of danger is, however, minimized if the direct ammonia process is used so that the ammonia is practically eliminated from the gas. At times there is trouble when naphthalene is present; it is deposited by the gas, particularly in cold weather, and easily obstructs the pipe-lines and valves. If benzol is recovered from the gas, no trouble from naphthalene can occur since it is absolutely necessary for an efficient benzol recovery to extract the naphthalene from the gas. Where this is not done, the gas pipes have not infrequently to be steamed out, in order to dissolve the naphthalene.

It has been suggested several times that a mixture of blast-furnace and coke-oven gas be used which might combine the good points of both and at the same time eliminate nearly all objectionable features. With a considerable compression pressure perfectly satisfactory results from the use of such mixtures in gas engines are assured and the heating value of such a mixture would be maintained uniform, if one could commit this task to the action of some automatic device. Where such a mixture is used now, its heating value is controlled by hand, and its composition appears to correspond very nearly to that of producer gas made from coke or anthracite coal.

The author gives a complete detailed calculation showing the final advantage of using a mixture of blast-furnace and coke-oven gas instead of straight blast-furnace gas for power generation in a gas engine plant as well as a calculation showing the comparative advantages of installing a 450-tons or a 350-tons capacity blast furnace, and on the whole comes to the conclusion that the unit cost of making coke-oven gas in a larger coking plant is a good deal less and the total revenues from the utilization of blast-furnace and coke-oven gases are considerably greater with larger than with smaller blast furnaces.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Proceedings, vol. 40, no. 4, April 1914, New York.

The Determination of Safe Yields of Underground Reservoirs of the Closed-Basin Type, Charles H. Lee
Cinder Concrete Floors, Guy B. Waite (abstracted)
Huacal Dam, Sonora, Mexico, H. Hawgood
Reinforced Concrete Docks, Harrison S. Taft (abstracted).

Reinforced Concrete Docks: Foreign and American Structures, Failures, Costs, and General Considerations, Harrison S. Taft (52 pp., *cdg*). While in the United States the construction of reinforced concrete docks is still in a very embryonic state and concrete structures in sea water have not always been successful, it has been used with complete success for more than 50 years in Europe for structure exposed to the action of salt water, and English engineers have been building reinforced concrete docks for about 20 years. The present paper contains a brief outline of the reinforced concrete dock problem as developed in Europe and Asia as well as a review of the art as carried on in this country both in sea water and fresh water. It takes up the subject of failures in past uses of cement in sea water in America and brings out the fundamental principles covering the successful use of concrete in structures exposed to salt water and frost action. It discusses also the question of the first cost of reinforced concrete docks as well as the cost of annual repairs. The first cost of the various reinforced concrete dock structures at Port Talbot is stated to have been "no more than if they had been built of wood," but such a statement would not perhaps be true in the United States on account of the large forests in this country. As regards the maintenance costs it is stated that the cold storage wharf at Southampton, England, has cost nothing for maintenance to date, while the widened dock and coal jetties are said to have shown considerable deterioration, due to rust of the steel which was improperly laid in the structure. The only repair charges on the Purfleet coaling jetty, exclusive of the damage done at the time of the collision, are stated to have been but $50 per year, which, based on its cost of $60,000, is less than one-tenth of 1 per cent.

The author then proceeds to review the opinions of foreign dock engineers on the use of concrete in sea water and on the practicability of reinforced concrete docks. Henry Hunter, chief engineer of the Manchester Canal, England, states that "the concrete in the concrete lock building in Eastham is in better condition at the present time than the day it was deposited." William Cleaver has stated that "while the reinforced concrete requires extreme care both in the choice of material and in the supervision of the workmanship, the results justify the extensive adoption of the material for dock work." Francis E. Wentworth-Shields, dock engineer of wide experience with the London & Southwestern Railroad Company, has stated that "if great care is exercised in making and placing concrete, an impermeable material will be obtained, which can withstand the action of salt water." He stated also that under certain circumstances reinforced concrete, when used in marine work, was likely to deteriorate, but did not think it would do so simply from standing in sea water, though in some cases deterioration had taken place at Southampton above low water, it had not done so below low water and during that whole experience at Southampton, sea water did not seem to have produced any chemical or deleterious action on the concrete. It would stand a wonderful amount of shock and bending due to shocks, if a wooden fender were interposed; on the other hand, reinforced concrete would not bear being knocked about by heavy ships and where structure was subjected to severe blows of that sort, it was not easy to find anything better than timber.

The author concludes that while it is true that all American cements are not yet wholly suitable for sea water purposes, successful marine reinforced work can be done here. But in spite of its apparent simplicity on dry land, the use of reinforced concrete in dock work calls for more than mere brawn and muscle. It is a class of construction work especially adapted to the broad knowledge, experience and deep study of the trained engineer in association with an organization well skilled in the handling of concrete in sea water structures.

Cinder Concrete Floors, Guy B. Waite (18 pp., 15 figs, 13 tables). In this paper the manner of using reinforced cinder concrete floor slabs by various cities in the eastern part of the United States is described. Especial attention is called to the arbitrary manner of using this material, and the insistence of continuing this arbitrary use, by New York City, as indicated by the latest building codes. Attention is called to the unit stresses adopted by various cities and to recent data tending to establish unit working stresses from actual tests. The qualifications of this material for the purposes described are discussed, and a comparison with stone

concrete is made. The manner of arbitrary testing is described, and the difference between the conditions of such tests and the actual loadings found in buildings is pointed out. Analysis is made of the arbitrarily approved reinforced cinder concrete floor slabs, showing the stresses which would be imposed on the materials by the maximum approved loads. Cinder concrete is described and tabulations are made for the location of the neutral axis and for the carrying capacities, assuming various unit stresses. The influence of the stresses due to an excess of steel or to an excess of concrete is discussed. Analyses of stresses allowed by such tests indicate that in some cases approvals have been given for dangerous construction; it is pointed out that arbitrary tests can be made which indicate carrying capacities not possible under the conditions actually found in buildings; and it is shown by formulations and tabulations that reinforced cinder concrete may be easily and uniformly designed by adopting working unit stresses, and that several cities have adopted such stresses for this material.

The author believes that in this paper he has amply demonstrated that the only manner in which this material can ever be uniformly used under various conditions is for each locality to adopt unit stresses suited to its own conditions.

ASSOCIATION OF ENGINEERING SOCIETIES

Journal, vol. 52, no. 4, April 1914, St. Louis

THE EFFECT OF SATURATION ON THE STRENGTH OF CONCRETE, J. L. Van Ornum (12 pp., 1 figs.). There appears to be little recorded information concerning the treatment of concrete specimens with regard to moisture conditions during their storage while awaiting the test for strength. It is, however, of great importance to specify and standardize the moisture treatment of specimens intended for testing. Since similar conditions act on the specimens as they act on the finished structures, it will affect their strength considerably, and therefore should be considered in specifying the proper unit stresses. This factor is of particular importance, as variations in strength, amounting perhaps to as high as 50 per cent above or below a mean value, result from differences in moisture conditions. This question of the effect of saturation on the strength of concrete has been investigated in the Washington University Testing Laboratory, especially with respect to the effect on the compressive strength of concrete produced by varying systematically the relative length of time of exposure in air and in water. The test specimens were cylindrical, 8 in. in diameter and 16 in. high. The materials were: a standard brand of Portland cement which fulfilled thoroughly all the requirements of the standard specifications; a clean sand of good quality, weighing about 110 lb. per cu. ft. when dry, and having 36 per cent voids; and a washed river gravel of the same weight, varying in diameter from quite small up to 1½ in., and having 33 per cent voids. The proportions were the usual 1:2:4, by volume; the mixing was done throughly by hand; and the quantity of water used was such as to give a moderately wet consistency, which allowed a thorough compacting by stirring with an iron rod and a slight tamping. All details of fabrication, curing, and testing were planned so as to secure such complete uniformity as is practicable to obtain in all regards except the one for which the controlled variation formed the particular purpose of the experimental study.

The cylinders were removed from the molds when two days old, and were tested at an age of six weeks. The intervening 40 days constituted the period in which the duration of their immersion in water was varied systematically from nothing to the full time. The average results of the 240 tests thus made are plotted in the diagram, Fig. 11, in which the abscissae represent that number of days (after the two days in the molds and the time of exposure to air) during which each set of specimens was placed in water before crushing them; and the ordinates give the percentage of strength which each set of immersed cylinders (standing in water for the indicated number of days) was found to have, taking the compressive strength of the dry specimens from the same mix as 100 per cent. Thus, at the extreme left is represented the basis of comparison, or those which were not immersed at all; those specimens which were cured

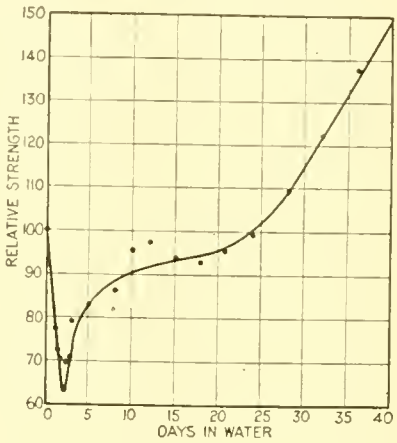


FIG. 11 RELATION BETWEEN SATURATION AND STRENGTH OF CONCRETE

in air of ordinary humidity for 32 days and then immersed for eight days are shown by the black circle to be 86 per cent as strong as the air-cured concrete; those in air for 12 days, and therefore finally cured in water for 28 days, have gained 9 per cent in strength; and those submerged for the entire 40 days exhibited an average compressive strength fully 50 per cent greater than that of the air-cured specimens.

An average curve for the plotted points has been drawn as a full line, showing the systematic increase in strength as the time of submergence is lengthened beyond two days; but there exists the significant fact that specimens, of the dimensions used, decrease rapidly in strength when stored in air for 38 days (or more) and then placed in water for the remaining two days (or less). This particular feature of the rapid loss of strength on first exposure to water, and the active but slower recovery of strength as soaking continued, required a multiplication of tests to determine satisfactorily the locus of the curve in this region; and consequently more than half of the experiments were concentrated in this descending and the adjacent rising portion of the plot.

CANADIAN RAILWAY CLUB

Vol. 13, no. 1, January 1914, Montreal

Cast-Iron Wheel Records, H. H. Vaughan (abstracted)
Cleavage and Crystallization, Griffin (abstracted)

CAST-IRON WHEEL RECORDS, H. H. Vaughan. 27 pp., 14 figs. *ds*). The problem of devising a correct method of keeping records of cast wheels used on a railroad is by no means

simple. Practically all railroads have abandoned any form of record which follows the history of each individual wheel. On some railroads a figure for the average life of wheels is obtained by dividing the number in service by the number removed per year, but this figure is not of much value, as it depends more on the rate at which the number of wheels in service increase than on the actual life of the wheels removed. At the same time the figure showing the life of the actual wheels removed can be obtained with considerable accuracy and with simple reports and records. But while the average life of wheels removed affords valuable information over a period of years, it does not enable the result of any variation in the quality or service of the wheel to be detected until considerable time has elapsed, and then only in a general manner. When the wheel foundry methods of the Canadian Pacific Railway were revised in 1908, it became desirable to introduce some system by which it could be determined whether or not better service results were being obtained without complications of the old individual records. This was accomplished in a satisfactory and simple manner by comparing each year's make of wheels, of the same weight and manufacture, with the number removed for various classes of defect in each year of their life. The information needed to do this was: make of wheel, weight, date cast, maker and cause of removal, items that were likely to be reported accurately, and those required for a record of any kind. As the number of wheels of any group cast in each year was known, the number removed in each year's life for each cause might be expressed as a percentage of the number made, and this percentage might be compared year by year to determine the comparative service obtained from the different wheels.

The author analyzed in considerable detail the records obtained in this way on the Canadian Pacific Railway, and then proceeded to describe the revision of the Canadian Pacific foundry methods in 1908, and results obtained since that date. In order to secure good wheels he considered the inspection which would detect those wheels, which for some reason departed from the accepted quality as one of the most important factors. It should be remembered that out of the ordinary lot of wheels 60 per cent will run through their life and be removed without any defect that reduces the life of the wheel, and better practice or improved inspection are really for the purpose of getting the other 40 per cent out of the way. As regards mixtures, the author states that it is a question to what extent charcoal iron is better than coke iron after being melted in a cupola heated by coke. A chilled wheel has only one serious point of weakness, the danger of broken flanges, and even that appears to have been greatly reduced since 1908 by the use of reinforced flanges, careful manufacture, good inspection and a rather hard wheel.

Cleavage and Crystallization, P. H. Griffin (2½ pp. *p*). Cleavage and crystallization are two of the fundamental factors in the manufacture and use of all articles of steel and iron, and are of great importance for a better understanding of all facts connected with the use of chilled wheels. A rapid and excessive heating of tread and flange by friction of brake shoes and their sudden cooling in wet and wintry weather readily accounts for what is known in railroad parlance as cleavages or cracks. Cleavage is the parting of a crystalline structure in certain lines, notably along the intercrystalline junctions. There are also cleavage lines which form without much regard for the intercrystalline junction lines; and it is to them, in the chilled surface of car wheels, that cracks are due. When the metal is of poor quality and high in impurities, the latter are thrown out as hot metal "freezes," so that finally, in the case of the chilled part of the tread and flange they lodge in the intercrystalline spaces, with a result that when the metal is heated and at the same time subjected to severe shocks and vibrations, the separation to the crystals of chilled iron becomes inevitable. To remedy this condition, the metal used should not contain excessive proportions of impurities, and not only sulphur, phosphorus, manganese, and the like, should be kept within proper limits, but oxides also. When the metal is fairly "clean" or pure it should be also of a quality that will form a crystalline structure without having excessive "smoothness" of the crystalline face.

INSTITUTION OF MECHANICAL ENGINEERS

Application of Electrical Driving to Existing Rolling Mills, L. Rothera (paper read on April 24, 1914, advance copy C. *dp*). The author discusses the important question of installing electrical drive in existing rolling mills, the best methods of doing it and where the system will pay. He takes up the subject from the point of view of economy of running, improved drive, considerations of space, and greater use of existing plant. As regards the economy of running, apart from the question of the cost of power, he discusses the influence of the layout of the works with particular regard to a plant which grew up gradually, and in which the boiler plant has remained centralized. As a result there would be a large number of long steam pipe lines, all acting the part of condensers and probably a number of them leaking considerably. These conditions will to a large extent hold even in the case of a works where there are several boiler stations, and the quantity of coal used per year in making over pipe-line losses and wastage is a very heavy factor in the year's coal bill. In addition to that in an old works there will be a large number of auxiliary machines driving shears, saws, punching machines, etc., which are working under most uneconomical conditions, being in nearly every case noncondensing and often almost undistinguishable when working, due to the steam leakage taking place around them. With electrical drive, the transmission cables can be put up anywhere out of the way and hardly any losses take place.

The next factor is the class of work done. The steam engine while efficient on steady continuous load, becomes very inefficient on a widely fluctuating load. An electrical drive varies only to the extent of 2 or 3 per cent over a very wide range, say from half-load up to 100 per cent overload. It may, therefore, be generally stated that the greater the fluctuations in the load, the more advantageous the electrical drive appears. As regards the question of *improved drive* the steady uniform turning moment produces a better class of rolled material than a pulsating drive. Another feature very noticeable with the motor drive is the faster working consequent from the fact that with the even turning moment there is not the same tendency for the rolls to fail to grip the metal. Also, due to the overload capacity of the motor being in excess of that of an engine, the drop in speed whilst the metal is passing through the rolls is much less with the electric drive than with the steam drive which results in

a higher average speed of rolling and increased output from the mill. Among other features which are also in favor of the electrical drive, the author mentions one, the importance of which is perhaps only appreciated by those who are acquainted with the electrical drive, which is the case of determining for every pass the power demanded for rolling. Electrical instruments will show with great exactitude the demand for power at any moment, and it is possible perhaps by varying somewhat the drafting of the rolls in accordance with these readings materially to reduce the energy consumption per ton rolled.

The author discusses also to some extent how the electrical drive may permit the utilization of the space available, and easy installation of increased power where such a thing would have been possible only at very considerable cost in the case of a steam engine.

With regard to the method of application of the drive there are four alternatives which he considers, namely, direct-coupled motor, a motor driving through gearing, through a belt and through ropes. *Direct-coupled drive* may now be had (as is done, for example, for heavy sheet mills) down to very low speeds, such as 32 r.p.m. and in a great many cases the extra additional cost of the slow-speed drive is more than counterbalanced by the gain in efficiency due to the absence of any form of transmission losses between the motor and the mill. The latter may become a heavy item in the yearly expenditure. In the case of gearing for varied conditions of working and when the gears have become somewhat worn, the losses taking place in a single reduction, represent hardly less than 5 per cent of the power being transmitted. With the *rope drive*, while the percentage loss is still a somewhat mooted point, it is probably safe to assume it also at 5 per cent and it must be specially borne in mind that the loss appearing in the ropes remains practically constant whether the ropes are running light or transmitting power, and *the loss can be taken on the normal power which the ropes are designed to transmit.* Belt drive is little used in England for this class of work.

Fig. 12 Direct Coupled Electrical Drive by means of Long Intermediate Spindle

In order to show in a simple form the losses which may occur in one year due to transmission, the author considers a case of sheet mill with a normal power of 600 h.p. on the motor and an average power of 200 h.p. taken by the mill, assuming that the mill is working for 110 hours per week and 50 weeks to the year. The losses in the case of gear drive would be 5 per cent of 200 h.p. or 10 h.p. for 5500 hours, and in the case of rope drive, the losses would be 5 per cent of 600 h.p. or 30 h.p. for the same number of hours, three times as much as in the previous case. Where, however, the question of converting an existing mill has to be considered, the method of drive adopted must be dependent to a very large extent on the layout of the works, as there may be other mills, roof columns or other reasons which may render anyone of the drives, otherwise advisable, impracticable. Then in the conversion of an existing mill must also be considered the question of the length of time for which the mill will have to be shut down in order to make the change. For this reason rope drive is very often adopted since the foundations of the motor and the motor itself can be put down without interfering with the working of the mill, and the mounting of the rope pulley is a matter of quite a short time, perhaps a couple of days. In the case of the direct-coupled drive, the method of avoiding stoppage is shown in Fig. 12, where a long intermediate spindle is introduced between the pinions and the motor, the spindle spanning the space taken up by the existing engine. The change from steam to electric drive in this case does not involve any stoppage of the mill. Sometimes it is possible to put the motor on the side remote from the steam engine and this was done on an electrically-driven reversing mill which has been working now for 5½ years and no trouble whatever has been experienced through its having been found necessary to transmit the drive through the bottom spindle to the pinions. Another advantage of such an arrangement is that the steam engine may be retained for use if necessary.

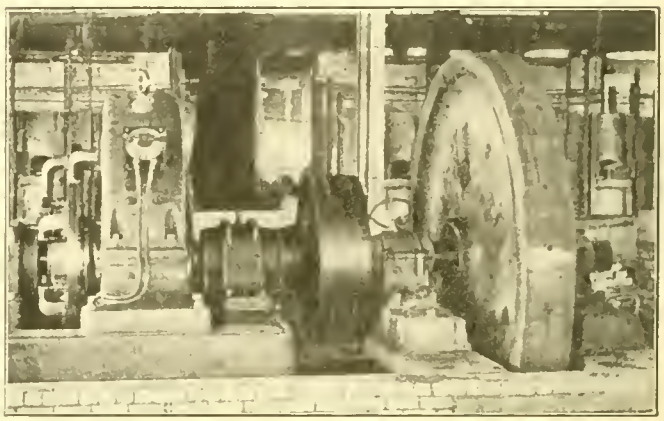


Fig. 13 Continuous Current Motor Coupled to Mill shown in Fig. 12

The weight of the flywheel when the motor drive is applied to a mill is a matter which has to be given serious consideration. It is not a safe method to assume that the existing engine flywheel will be satisfactory for the motor drive. In the case of an engine, the whole of the stored energy in the flywheel is available to pull the metal through the rolls in conjunction with the engine, while the motor has a predetermined drop in speed from no load up to a maximum load which it can safely stand. Assuming, in the latter case, that there is a 20 per cent fall in speed between no load and 100 per cent overload, only 36 per cent of the stored energy is available, after which the motor ceases to drive, leaving only the flywheel stored energy. To some extent this is counteracted by the fact that the permissible overload on the motor will be 100 per cent in excess of the normal power, while in the case of the engine, the overload will not be much more than 25 per cent, but as a rule the motor drive will require a heavier wheel than the engine drive. Providing, however, the maximum peaks are not excessive, a fluctuating load

will not prove harmful to a motor and the weight of the flywheel may be mainly decided from the point of view of cost. Whether to have a large slow-speed, or a smaller, high-speed flywheel is mainly a matter of cost, but the difference is not in many cases very great on account of the fact that the full peak loads of the mill in the latter case have to be transmitted from the motor and flywheel through gearing or ropes, as the case may be, and the size of the gearing and number of ropes will have to be materially increased to withstand this extra strain. In one or two cases the flywheel has been mounted on the motor shaft and the drive through a worm reduction gear on to the mill used. This is an interesting new departure and would appear to be a very satisfactory method if a steady power is demanded, such as for instance in a wire mill or cold roll drive in a tin plate mill where there are no heavy peak loads to be taken by the flywheel, but it is yet to be seen whether it can be made sufficiently strong to last where the full power of the motor and flywheel has to be transmitted through such a gear.

IRON AND STEEL INSTITUTE

Failures of Heavy Boiler Shell Plates. (Presented at the May meeting, reported from an advance paper, 29 pp., 3 figs. in the text and 9 plates. *e*). The author describes a number of cases of failures of heavy boiler shell plates with an indication of the facts revealed by the subsequent investigation of the causes, and concludes that the longitudinal tensile tests, even when taken near the fracture, seldom reveal any abnormal features and transverse tests are more successful; in nearly all the cases dealt with the bend tests were satisfactory, although at first sight it seems somewhat of an anomaly that a piece of plate can be bent through 180 deg. while the whole plate fractures at a very slight angle. The conditions are, however, wholly different: in a bend test, the metal can flow with very little restriction, while in the plate very little lateral flow is possible, so that in a plate the metal is subjected to pure stretch and compression. This fact is of special importance in considering the effect of hammer dressing, as though it is frequently possible to bend a strip of steel after being hammered on the outer surface, it does not therefore follow that hammering a wide plate would be equally innocuous. In general, however, the breakdown is the result of a simultaneous occurrence of several defects, and, for instance, it is not sufficient to say that the plate failed because it was segregated. There is little doubt that there are many more or less segregated plates in boilers, but they have not failed as no adverse conditions were present. A good plan in dealing with a failure is to estimate the percentage value of the different causes producing the fracture with a clear understanding, of course, that such values are only approximate estimates. Hammer dressing may be one of the causes of failure and it is used only because a little hammering frequently saves a good deal of chipping and buffing. It has been pointed out before that severe internal stresses may exist in heavy plates, as their stiffness prevents them from buckling in the manner that thin plates do when the rolls are not true, and this cause may be a factor, perhaps the principal one, in producing failures. In addition to the rolls being actually untrue or having become so when hot, there is also the risk of internal stresses being set up through the plate being subjected to rain from a leaky roof, or from having other plates piled on it when hot. The latter must be considered a bad practice in every way as very serious stresses may be caused through plates only partially covering each other, so that one part of the plate is almost cold while the other is still at a red heat, and it is quite conceivable that this might be sufficient to produce failure. Even if the plate is wholly covered by another, it is possible that it may be maintained at a dangerous temperature of 700 deg. cent. (1292 deg. fahr.), thereby producing brittleness by partially converting pearlite into cementite. The only satisfactory way to insure that heavy plates are as free as possible from internal stresses is to anneal them, and even in this there are several pitfalls to be avoided. For example, mild steels containing a fairly high percentage of phosphorus require very much more drastic annealing than those with a small percentage. It is also of great importance that the whole plate should be raised to the same temperature when being annealed and it is not an easy matter to effect with large plates. In most of the plate investigated after failure the chemical composition is not abnormal, sulphur and phosphorus being not in excess 0.06 per cent, but in large plates, where the work done on them is comparatively small, it is necessary for the metal to be exceptionally pure. Phosphorus and sulphur segregate so much that although a certain percentage would be harmless enough if distributed evenly, it may produce failure owing to these segregations. For this reason it is suggested that 0.05 per cent should be the phosphorus limit, especially if there is an appreciable quantity of arsenic present. Phosphorus has also a strong tendency towards turning pearlite into cementite, which occurs also if the plate is heated for some time at the temperature below 700 deg. cent. or 1292 deg. fahr.

The author discusses at length the question of manholes and finally recommends, in order to eliminate the risk of failures, the use, first, of large ingots; second, effective handling (the pyrometer always being used and a record kept of the temperature to which each plate was subjected, as well as the length of time it was in the annealing furnace); third, low phosphorus not to exceed 0.05 per cent or with arsenic 0.06 per cent; fourth, inspection of all parts which require dressing by an independent inspector, and, fifth, occasional transverse tests to be taken from the centers of the ends or sides of the plates corresponding with the longitudinal axis of the ingot.

Some Recent Improvements in Case-Hardening Practice, Henry L. Heathcote. (33 pp., 4 plates. *de*). The author presents his paper in the form of an account of what has been done on improving case-hardening practice at the Rudge-Whitworth Works. The first problem was to find an improved pyrometer which could be used in a plant having a battery of 13 muffles (the Féry instruments were then unknown). This problem was solved by evolving a color pyrometer based, first, on the fact that the spectrum of a red-hot piece of steel is found to elongate at both the red and violet ends and to increase in intensity all along as the temperature rises, and, second, in finding solutions capable of absorbing the rays emitted by red-hot steel and at various temperatures. The solutions chosen were then properly calibrated and this gave finally a convenient pyrometer. The author's opinion is that a pyrometer which indicates its own temperature may convey some idea of the temperature of the work, but will never be the hardener's friend to the same extent as one of the forms of optical pyrometer, which can

be focused on the article itself, such as the one used at the Rudge-Whitworth works.

Next came the question of investigating case-hardening compositions, their mode of action and effect. Experiments extending over a considerable range of compositions have confirmed the following suppositions: (*a*) the depth of case depends chiefly on the temperature the steel attains and the duration of the hot condition; (*b*) the concentration of the carbon in the case depends chiefly on the rate at which the mixture or its products give up carbon to the steel.

The author also noticed considerable influence of gases, possibly nitrogenous, evolving from the mixture on the efficiency of carbonization. He made a number of "exhaustion" tests, that is, tests to determine after how many heats the mixture is exhausted, this being attained when ferrite bands can be seen between the pearlite grains at the periphery. He found that the best mixture on the score of permanence is wood charcoal, impregnated with soda ash. It can be used practically over and over again indefinitely. It is unlikely, however, that the carbonizing power of mixtures is due to nitrogenous compounds or cyanides, since charcoal soaked in a 5 per cent aqueous solution of sodium carbonate and dried, after three heatings contained 0.12 per cent of nitrogen and no cyanide, and still gave a saturated case even after the tenth, eleventh and twelfth heatings. As regards the permeability to heat, he investigated the influence of the size of particles on the rise of temperature (Fig. 14) and found that the effect of size of grain and particularly of dust is quite material, especially upon the duration

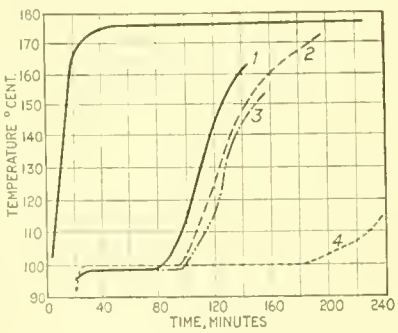


Fig. 14 Influence of Size of Particles on Rise of Temperature in Case Hardening

of the arrest, and that there is an arrest of temperature at the center at about 100 deg. cent. (212 deg. fahr.) while moisture is being driven off. When the same samples were again heated the temperature rose more quickly, with no arrest, the latter fact being due of course to the moisture having been expelled during the previous tests. This makes a mixture, which can be used over and over again, particularly convenient in that the moisture, oil and other volatile constituents should for the most part have been already expelled during the previous heatings.

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 19, no. 4, April 1914, Chicago

City Transportation, Subways and Railroad Terminals, Bion J. Arnold
Wind Loads on Buildings, Albert Smith (abstracted)
The Making of a Technical Journal, E. J. Mehren

Wind Loads on Buildings, Albert Smith (24 pp., 13 figs. and 2 data sheets, *cA*). Last Spring the author carried out tests on roofs of the type of large structures, such as drill-halls and train sheds. The model represented a roof of semi-circular section 6 ft. span and 10 ft. long, covered with tin. It was mounted on walls 5 ft. high. After each set of observations, the roof was lifted and 6 in. of the wall taken off. The walls were made of 2 by 6 lumber, tongued and grooved, the latter making them both comparatively

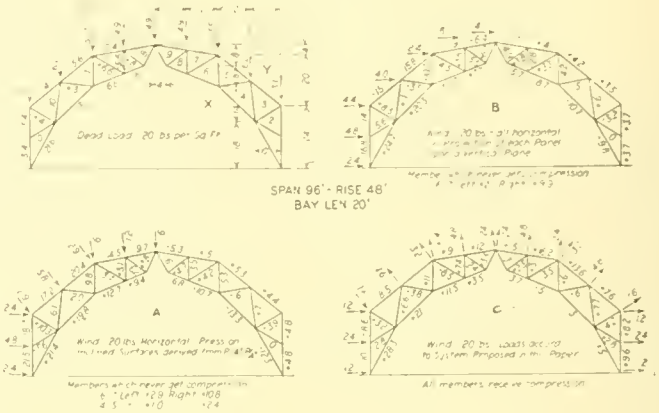


Fig. 15 Stresses in Two Hinged Arch from Three Systems of Wind Loading

tight and somewhat stiff when an end or side was omitted in the course of the tests. The author describes in detail the pressure-registering instruments and the method of taking the observations, as well as the method of calibrating the pitot tubes. He derived a number of pressure diagrams for various winds and also made a number of observations with portions of wall removed. He found that the forces on the building with one side open, while greater than for one of the same height with the side closed, did not exceed the proposed units. With the wind in the other direction, the pressure on the closed wall would be increased by a rarefaction inside the house, and the suctions over the roof would be diminished. Observations on the model with both sides removed show that the stresses for this case are less in amount, and nearly the same in distribution as for the closed house. A comparison of the stresses in a very simple two-hinged arch from three systems of wind loading is shown in Fig. 15. It appears that if the wind loads are as shown by the test described, not only are the stresses assumed to be much too large in most cases, but in two cases they gave tension only in numbers which should be designed for compression. This truss is of exaggerated depth, and in a large truss of ordinary depth the discrepancies would be greater. Such arches are now made entirely of compression sections in most cases, but it would be better to adopt a loading system which makes it impossible to do otherwise. In another illustration the author shows the same comparison for a mill building bent. As in the arch, all members received compression from the proposed loadings, while by the common method three of these members would 14) and found that the effect of size of grain and particu- be designed for tension only. (For the current formula of wind stresses on buildings and its criticism see article on p. 117.)

PERSONAL NOTES

George A. Orrok, member of the Council, who has been absent from the city for over a year on account of illness, has recovered his health sufficiently to return, but will not resume his duties with the New York Edison Company until the fall. The faithful service which he has rendered in connection with the Gas Power Section will be carried on in connection with the change from a section to a committee with powers similar to those of other sub-committees of the Committee on Meetings.

Ellis Soper, president of the Soper Engineering Company of Chattanooga, Tenn., has been selected as construction engineer for the Market Street bridge of that city. The design will be of concrete and will conform with Government specifications. It will be a low bridge with a lift span over the water channel, the span being about 275 feet long and of steel construction. Mr. Soper's largest work in the South thus far has been the construction of the plant of the Dixie Portland Cement Company at Richard City.

Prof. R. H. Fernald of the University of Pennsylvania was recently appointed consulting engineer of the U. S. Bureau of Mines.

T. Kennard Thomson addressed a meeting of the Maritime Association of the Port of New York on May 4, giving an outline of a plan for a really greater New York. This contemplates the annexation of Manhattan to Long Island by filling in the East River, as well as other equally important topographical changes of the harbor and water front. Mr. Thomson estimates that this could be done in five years.

Frank B. Gilbreth has been appointed Honorary Vice-President to represent the Society at the opening of the new society house of the Verein deutscher Ingenieure on June 5. Mr. Gilbreth is now abroad investigating conditions of management in Germany.

H. Alfred Ellis has been elected president of the Light Railway Equipment Company of Chester, Pa. He was formerly associated with the Orenstein-Arthur Koppel Co., Koppel, Pa., in the capacity of general superintendent.

Albert W. Thompson has accepted the position of managing engineer of The G. M. Parks Company, Fitchburg, Mass. He was until recently connected with the Saco-Lowell Shops, Lowell, Mass., as superintendent.

John Lathrop Gray, formerly associated with the Tide Water Oil Co., Bayonne, N. J., as assistant general superintendent, is now identified with the Pierce Oil Corporation, St. Louis, Mo., as manager of the refining and producing departments.

George C. Thomas has been appointed superintendent of The Singer Company, Podolsk, Moscow, Russia. He was formerly connected with the Bridgeport, Conn., factory of the company as assistant superintendent.

Edmund Mackenzie has taken a position with R. Blakstad, who is one of the foremost engineers and promoters of Norway, as supervising engineer on construction work on high head hydraulic developments, power transmission, substations, factories, etc., with headquarters at Kristiania.

M. H. Roberts is affiliated with Mead Johnson Company, manufacturing chemists, Jersey City, N. J., as consulting engineer.

STUDENT BRANCHES

Members of student branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate receipt of The Journal.

COLUMBIA UNIVERSITY

T. E. Sperry lectured on the Gyroscope for Marine Purposes at a meeting of the Mechanical Engineering Society of Columbia University in conjunction with the Electrical Engineering Society on April 14. The points covered were the advantages of the gyro-compass over the magnetic compass; the operation of repeater compasses located at different parts of the ship and their control by a master compass situated below in a well protected place; the adjustments necessary to correct for the speed of the ship; the use of the gyroscope as a stabilizer for ships and aeroplanes. The lecture was illustrated with lantern slides.

On May 6 the following officers were elected for the year 1914-1915: H. T. Allen, chairman; W. L. Garrison, vice-chairman; A. S. Henry, secretary; J. T. Hanlon, treasurer.

KENTUCKY STATE UNIVERSITY

The Economic Use of Coal by Communities was the subject of a paper by Prof. John T. Faig, Mem.Am.Soc.M.E., before the Kentucky State University Student Branch on April 18. The author's idea was to convert bituminous coal, which causes so much damage to our cities from smoke and which is not an ideal fuel for residences, into two ideal fuels by means of coking ovens, coke and coal gas. These products are better than coal as fuel for the house or factory. The other products of the coking oven, tar, benzol and ammonia sulphate, are each valuable to the industrial world: benzol will find a market as a substitute for gasolene; figures given by Professor Faig showed that by buying coal at prices prevailing in the Ohio Valley the coke and coal gas can be sold at prices within reach of all and the sale of the other products will make it a profitable business.

LELAND STANFORD JUNIOR UNIVERSITY

On April 28 the Stanford Mechanical Engineering Society elected the following officers to serve from September to December 1914: J. A. Gibb, chairman; L. Swayne, vice-chairman; C. L. Addleman, secretary-treasurer.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At the meeting of Massachusetts Institute of Technology Student Branch on April 22, H. F. J. Porter, Mem.Am.Soc.M.E., read a paper on Fire Traps—Fire Escapes—Fire Drills versus Sectional Buildings.

On April 29 the society held its annual banquet and election of officers: F. G. Purinton was chosen chairman; N. E. Kimball, vice-chairman; H. E. Morse, secretary; G. A. Palmer, treasurer; and F. L. Cook, W. R. Hanchett, O. C. Norris, governing board. Charles T. Main, Mem.Am.Soc.M.E., was the first speaker of the evening and chose as his topic, Professional Ethics. He was followed by William Kent, Mem.Am.Soc.M.E., who defined the word "engineer"; Prof. G. B. Haven, Mem.Am.Soc.M.E., who gave the seniors advice on starting on their business careers. Prof. G. E. Russell then told of some interesting discoveries concerning the Pyramids, and Prof. E. F. Miller, Mem.Am.Soc.M.E., closed the evening with a talk concerning the Society.

On May 5 H. J. DeBear, of the Maxwell Automobile Company, gave an illustrated talk on the complete process of manufacture of the automobile from the ore to the finished product. The author dwelt at some length on the testing of the raw materials and the finished product, and showed many of the parts in process of manufacture. Moving pictures were used to illustrate the lecture.

PENNSYLVANIA STATE COLLEGE

On April 23 H. L. Swift read a paper before the Student Branch of Pennsylvania State College on The Manufacture of Glass by Machinery. He followed the process through its different stages from the batch-making room to the packing house, and told of the operations where machinery has re-

placed hand labor with considerable saving in the cost of manufacture and betterment of quality.

At the May 15th meeting, W. D. Garman presented a paper on The Machining and Assembling of Steam Engine Parts, and the following offered discussion: Prof. J. A. Moyer, Mem.Am.Soc.M.E., Professor Bates, and C. F. Kennedy.

POLYTECHNIC INSTITUTE OF BROOKLYN

On April 25 the Polytechnic Institute Student Branch held its third annual banquet. The speakers were Fred. W. Atkinson, President of the Institute, Samuel M. Tucker, Wm. D. Ennis, Mem.Am.Soc.M.E., and Calvin W. Rice, Secretary of the Society.

At a meeting on May 2 the following officers were elected for the ensuing year: M. Van Valkenburgh, chairman; S. P. Blakeman, vice-chairman; Samuel Kobre, secretary; C. J. Koff, treasurer. Leon A. Eben read a paper on Parliamentary Procedure, which was discussed by A. A. Adler, Mem.Am.Soc.M.E., and Messrs. Tyler, Sand, Postman, Isenberg and Merkt.

RENSSELAER POLYTECHNIC INSTITUTE

At a meeting of the Rensselaer Polytechnic Institute Student Branch on April 30, R. L. Manier lectured on the Production of Carbureted Water Gas and illustrated his talk with lantern slides. C. E. Davies presented a paper on Up-to-Date Office Methods in Large Manufacturing Plants.

STATE UNIVERSITY OF IOWA

The Student Branch of the State University of Iowa held a joint meeting on April 21 with the Electrical Engineering Society and the Compass Club, at which Prof. S. M. Woodward, Mem.Am.Soc.M.E., read a paper on Flood Prevention In and Around Dayton, Ohio. The author is one of the consulting engineers employed on the project. The lecture was profusely illustrated by slides showing flood conditions, the results, and the methods suggested to prevent a recurrence.

At a meeting of the branch on May 5, H. J. Kicherer gave an illustrated talk on Automobile Manufacturing.

STEVENS INSTITUTE OF TECHNOLOGY

The Stevens Engineering Society held a debate with the Sibley College Student Branch on May 11. The subject was Resolved, That Public Utilities of Municipal Scope Should be Owned and Operated by the Municipality (electric light, gas and water plants only to be considered). Benjamin P. Goldman of Sibley College upheld the affirmative, and divided his arguments as follows: (*a*) public utilities are natural monopolies and, as such, are dangerous; (*b*) regulation of public utilities by commission has to date proved unsatisfactory; (*c*) why deal with a poor subterfuge such as regulation when the community will be benefited financially by municipal ownership. In proving the last two points the affirmative cited instances where the rates charged for electricity had been reduced in the case of municipal ownership from $0.125 to $0.05 per kw-hr., while the Chicago Lighting Company had declared a dividend of 24 per cent during the last year. The negative side was treated by C. H. Colvin of Stevens under the following heads: (*a*) the proposition should be viewed from the point of cost of service ratio; (*b*) the elimination of profits is more than made up for by the increase in the cost of materials, running expenses and wages under municipal ownership; (*c*) graft becomes easier under municipal ownership than under private operation; (*d*) that data for comparing the relative cost of production under the two forms of ownership are unreliable since the factors of depreciation and taxes are not generally taken into account in preparing these estimates under municipal ownership, while they are under private operation. Frederick R. Hutton, Past-President and Honorary Secretary of the Society, Charles Whiting Baker, Mem.Am.Soc.M.E., and Mr. March, Stevens 1914, acting as judges, decided unanimously in favor of the affirmative.

UNIVERSITY OF CALIFORNIA

On April 21 the University of California held its final meeting of the year, and the following officers were elected: A. C. Moorhead, chairman; L. T. Kennedy, vice-chairman; H. L. McLean, secretary; B. R. Abbott, treasurer. L. T. Kennedy discussed a paper, Power from Mercury Vapor, which appeared in the Transactions of the American Institute of Electrical Engineers; and W. W. Penniman, Surface Combustion, which appeared in the American Gas Institute Journal.

UNIVERSITY OF COLORADO

The University of Colorado Student Branch, at a meeting on May 13, elected the following officers for the coming year: L. J. Brady, chairman; Ben Christian, vice-chairman; S. S. Cooke, secretary-treasurer.

UNIVERSITY OF ILLINOIS

On April 16 at a meeting of the University of Illinois Student Branch, M. E. Hodgins, of the Goodrich Rubber Company, gave an interesting talk on rubber, during the course of which he traced the growth of the industry from the time of Columbus to the present day. On May 7 Prof. A. C. Willard spoke on The Organization of the Engineering Office of the Chief Quartermaster Corps of the United States Army, with which he was formerly connected.

UNIVERSITY OF MISSOURI

The Missouri University Student Branch held a meeting on April 20 at which S. G. Goodman presented a paper on Fire Prevention and Fighting in Our Shops and Factories. P. R. A. Notting followed with a paper on Aerial Motors and the Trouble That Had to Be Overcome in Some of Them. On May 4 an illustrated lecture was delivered before the electrical and mechanical engineering branches on the Engineering Societies Building, New York.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. The published list of "men available" is made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. Further information will be sent upon application.

POSITIONS AVAILABLE

420 Chief engineer with jurisdiction in all engineering questions over plant, equipment, mechanical methods and products. To qualify, applicant should have technical training and wide experience, chiefly in metal working of the lighter and finer kinds, also in planning construction of buildings and designing and operating of power plants. Name confidential; apply through the Society.

507 Three railway construction engineers with a number of years experience, about 35 or 40 years of age, for positions with government railway in New South Wales. £100 traveling expenses allowed to Sydney. Salary £500 per annum.

508 Mechanical and electrical engineer, who understands some Spanish, and capable of taking charge of a producer gas power plant in Ciudad, Bolivar, Venezuela. Traveling expenses paid to Venezuela.

509 Technical graduate desired who is familiar with the theory, present practices and the manufacturing of centrifugal and turbine pumps. Must have had actual experience either as chief or assistant designer. Ability to estimate on costs. Give full details covering education, shop and business experience, references, age, etc. Name confidential; apply through the Society.

510 Man of engineering training between the ages of 25 and 35, with experience in the productive or executive de-

partments of large factories, to fill position as assistant to head of a manufacturing department in factory in New Jersey. Salary about $1500 per year, depending upon qualifications. Give detailed history of business career. Apply through the Society.

511 Energetic, young man, well educated, with a knowledge of mechanics, and a good correspondent in sales department of a large manufacturing company in New England. Graduate mechanical engineer with some commercial experience preferred. A full reply giving age, whether married or single, experience, present occupation, references and salary expected will receive attention and will be treated confidentially. Name confidential; apply through the Society.

514 Draftsman and maintenance engineer for service and maintenance department of large electrical supply concern. Location, New York.

518 Consulting engineer controlling valuable patents relating to gas engines desires to become associated with engine building concern for the development of the engines covered by these patents.

519 Mechanical, metallurgical and chemical engineer competent to take charge of a research laboratory, to make tests of the strength of materials and devise special processes, etc. Exceptional opportunity. Location, Maryland. Name confidential; apply by letter.

520 Assistant to executive. Experience required in handling men; competency to design small and medium size machinery for strictly interchangeable work; familiarity with modern shop practice and tooling. Salary $2500 to $3000. Location, Maryland. Name confidential.

MEN AVAILABLE

F-500 Mechanical engineer, graduate of a leading university, wishes position in which good future can be anticipated. Age 30; married; nine years experience drafting, designing, construction and maintenance work; considerable electrical experience, in charge large high-tension apparatus.

F-501 Technical graduate, age 37, with continuous experience since graduation in engineering work, chiefly in design of power plant, mining and mill machinery. More than ten years in charge of work as chief draftsman and chief engineer.

F-502 Graduate in mechanical engineering with some shop and drawing room experience desires instructorship in mechanical engineering branches for the coming school year.

F-503 Assistant to executive; graduate mechanical engineer, '09, with business experience, organization, management. Junior, age 28, married.

F-504 M. I. T. graduate, with experience on instructing staff and four years experience in efficiency engineering and scientific management in power, manufacturing and auxiliary departments. Desires further work along this line or permanent executive position with concern desiring energy and ability.

F-505 Associate-Member, technical graduate, seven years experience, recently completed work as mechanical engineer in charge of erection work for smelter and large power plant. At present in charge of plant, transmission line and repair shops. Desires similar position, or in designing office.

F-506 Junior, university graduate, at present occupied in teaching mechanical engineering laboratory practice in one of the large eastern technical schools, desires employment for the four summer months, preferably with efficiency engineers, or company installing scientific management. Practical experience in central station work. Well recommended.

F-507 Junior, age 28, graduate mechanical engineer, desires position with engineering firm or industrial plant. Location immaterial. Five years experience in design, testing, operation, and management of power machinery. Steel mill and electrical experience.

F-508 Specialist in the practical manufacture of pumps, steam, gas, oil, gasolene and kerosene engines; sales work and power plant construction, and until recently vice-president of a million dollar corporation manufacturing all forms of pumps and prime movers. Desires connection with concern of some importance in capacity of engineer, or preferably, sales work.

F-509 Graduate mechanical engineer; age 24; now employed as assistant superintendent and purchasing agent in a company making gasolene motors and other lines. Desires to get into purchasing or sales work. Has had experience in shop, and as assistant chief engineer in large engine and boiler concern.

F-510 Junior, graduate mechanical engineer; age 24; desires position in connection with machine tools or prime movers. Has had responsible positions as designer and mechanical engineer. Seeks opportunity for greater development. Salary desired, $1500, but experience to be gained and opportunity for advancement will be considered first. Best references. New York preferred. Address through the Society.

F-512 Member, age 34, professor of mechanical engineering subjects; would prefer small school which is growing rapidly. Graduate of Cornell University; eight years experience in engineering, from draftsman to chief engineer; three years teaching in one of the largest engineering schools; can handle any subjects in mechanical engineering course; especially strong in experimental engineering. Best references. Desires change to assume more responsibility.

F-513 Associate-Member, age 36; government, railroad and factory connections; competent to take care of plant engineering, also work incident to control of materials; some experience in appraisal, purchase and cost departments.

F-514 Junior, age 31; seven years experience in gas and electric business; wishes to locate in Middle West in same line of work. At present employed.

F-515 Member, at present employed, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position; 18 years varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; testing and general plant engineering; familiar with the handling of men, drawing up of contracts, purchasing equipment and material, appraising properties; modern methods of manufacturing and marketing product.

F-516 Member, with exceptional technical training, both mechanical and electrical; five years experience in research work on steam turbines, centrifugal air compressors and jet pumps; four years complete charge of designing, manufacturing, testing and installing vacuum cleaner systems, including the development of a complete line of portable and stationary vacuum cleaning machines; desires position with a good firm of consulting engineers, with prospect of ultimate interest in the firm; or would consider position with good manufacturing firm. At present employed.

F-517 Junior, age 38; sales engineer, experienced in handling high-grade power transmission and mechanical specialties; desires to represent manufacturer; eastern territory in United States, or England preferred.

F-518 Member; technical graduate, 31 years of age, desires position as works manager, mechanical superintendent or efficiency expert with company of consulting engineers or large manufacturing corporation; extensive training and experience in central power station work, designing, purchasing, superintending construction and operating depart-

ments; consulting engineering work on large properties; power production investigations; cost reduction; experienced in mill and reinforced concrete construction work. At present employed, but desires a change for advancement.

F-519 Sales engineer, Junior, progressive with successful selling experience; wishes connection with high-class manufacturing company desirous of representation in Chicago and Middle West.

F-520 Executive, technically educated as a mechanical engineer, who, under titles of assistant vice-president and secretary, has served as a general utility man for well-known manufacturers of machinery; duties included sales, advertising, development of new ideas, pushing out work and general office management; seeks a responsible position where a wide engineering knowledge will be of value.

F-521 Associate-Member, age 29, married, graduate M.E. 1908; experience in designing and developing new and original devices in machine shop; erections and installations, testing and selling. Good knowledge of water works and power plant equipment. Desires a position of responsibility or where the outlook for the future is bright for the man who can prove good.

F-522 Summer Position—instructor of mechanical engineering in an Eastern Institution, desires a shop position; age 26; four years experience in gas engine manufacture; available about June 15th.

F-523 Member, with European technical education, desires connection with large industrial or manufacturing firm. Thirteen years experience in various branches of engineering, including the design and development of special machinery and process equipment; layout, design, construction, equipment and maintenance of manufacturing and industrial plants. Conversant with the most modern, efficient and economical methods; has executive ability, a good handler of men, willing to assume responsibility, and able to take independent charge of industrial engineering work from the preliminary investigation to the completion of the work. Now employed.

F-524 Member, technical graduate, desires position as works manager or general superintendent, experienced in foundry and machine shops, a good executive and manager of men.

F-525 Mechanical engineer, age 27, four years experience as a machinist, two as assistant chief engineer of a firm manufacturing engines, boilers, etc.; knows how to work harmoniously with other men and has executive ability. Would consider position with a progressive firm in charge of department, or in charge of production and time setting. At present employed.

F-526 Executive engineer, recently general manager of an important manufacturing business, rigid experience in carrying out large operations. Has been successful in controlling men and reducing cost of handling material; 35 years of age.

F-527 Sales representative established in New York City desires to correspond with manufacturer to secure an additional account. A-1 standing among manufacturers, engineers and contractors.

F-528 Cornell graduate, mechanical and electrical engineer with broad experience in design, erection, operation and appraisal of public service and industrial properties, factory maintenance and operation, and sales engineering. Desires a permanent position with consulting engineers or manufacturing company in or near New York City. Appraisal engineering preferred.

F-529 Member, at present employed, desires to be identified with manufacturing or industrial plant in responsible administrative or executive position; 18 years varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; testing and general plant engineering; familiar with the handling of men, drawing up contracts, purchasing equipment and material, appraising properties; modern methods of manufacturing and marketing product.

F-530 Cornell graduate in mechanical engineering, seven years continuous experience; consulting engineering officer, preparation of plans, specifications, supervision of installations; also management of hardware and tool manufacture.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

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American Type Founders Company. Guide to the exhibit of the typographic library and museum, at the second national printing exposition, Grand Central Palace, April 18-25, 1914. Gift of company.

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Die Berechnung der frei aufliegenden, rechteckigen Platten, Heinrich Leitz. Forscherarbeiten auf dem gebiete des Eisenbetons, pt. 23. *Berlin, 1914.*

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Compressed Air, Theodore Simons. *New York, McGraw-Hill Book Co., 1914.*

A book designed primarily for students which omits the extensive description of every existing type of compressor and the countless appliances using compressed air. It is well provided with problems for the students.

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THE MNEMONIC SYMBOLIZING OF STORES UNDER SCIENTIFIC MANAGEMENT, H. G. Benedict. Gift of H. Uheland.

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The author states in his preface that his object is "to set forth the metallurgy of the steel foundry from the standpoint of the engineer, . . . whose usefulness consists in prescribing the cheapest means of producing objects or structures of sufficient excellence for the purposes for which they are intended." A chapter is given up to heat treatment and annealing, and one to "building up" impurities in steel. There have been few works on steel castings, and this seems a valuable addition to the literature of the subject.

TAR FORMING TEMPERATURES OF AMERICAN COALS, O. C. Berry. University of Wisconsin. bul. no. 635. *Madison, 1914.* Gift of A. G. Christie.

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AMERICAN BLOWER CO., *Detroit, Mich.* Bul. no. 35, pitot tube and fan testing, January 1914.

BROWN INSTRUMENT CO., *Philadelphia, Pa.* Cat. no. 9, Brown pyrometers.

CARBONDALE MACHINE CO., *Carbondale, Pa.* Bul. no. 11, modern distilled water can ice plant, February 1911; bul. no. 12, ice making with the Carbondale evaporator system, February 1911; bul. no. 14, ten to one ice plant, August 1913; bul. no. 16, helping the competitor, June 1913; machinery for the manufacture and liquefaction of carbonic acid gas, 1914.

CHAPMAN VALVE MANUFACTURING CO., *Indian Orchard, Mass.* Cat. and price list, no. 31.

DAVIS-BOURNONVILLE CO., *Jersey City, N. J.* Oxy-acetylene welding and cutting apparatus, 31 pp.

ELECTRIC STORAGE BATTERY CO., *Philadelphia, Pa.* Handbook H L, low voltage isolated electric plants for lighting and power with Chloride Accumulator, March 1914; Handbook HP, chloride accumulator for use in 110 volt isolated lighting and power plants, August 1912.

ELECTRIC WEIGHING CO., *New York, N. Y.,* messiter conveyor scales.

FAIRBANKS-MORSE & CO., *Chicago, Ill.* Bul. 27, direct-current type CP motors and generators; bul. 29, direct-current type TRC motors and generators; bul. 202H, alternating-current type B constant speed induction motors; bul. 210, internal starter motors.

KENT MILL CO., *Brooklyn, N. Y.* Bul. 39, maxecon mill; bul. 40, perfectecon separator; bul. 41, mexecon mill grinding plant.

KEWANEE BOILER CO., *Kewanee, Ill.* Cutting coal costs.

MAX AMS MACHINE CO., *Mt. Vernon, N. Y.,* seal of safety, 1914.

NORTHWESTERN EXPANDED METAL CO., *Chicago, Ill.* Expanded metal construction, May 1914.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

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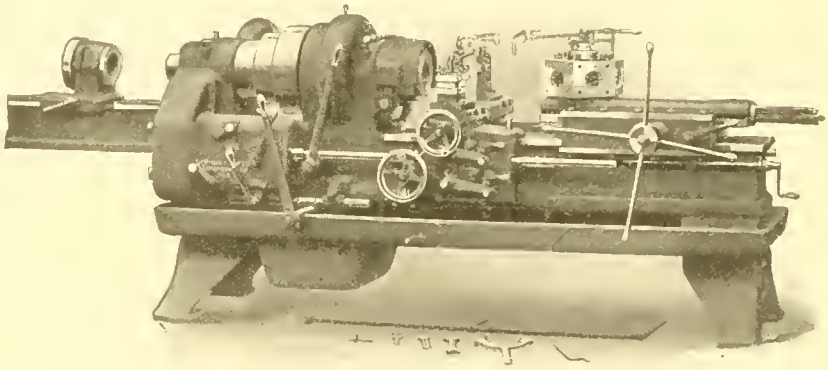

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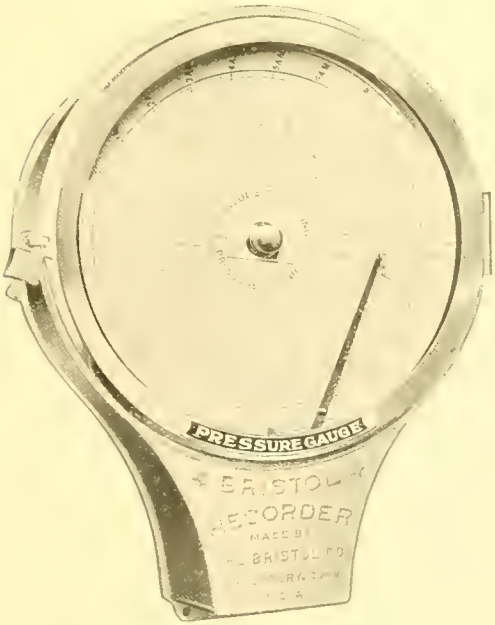

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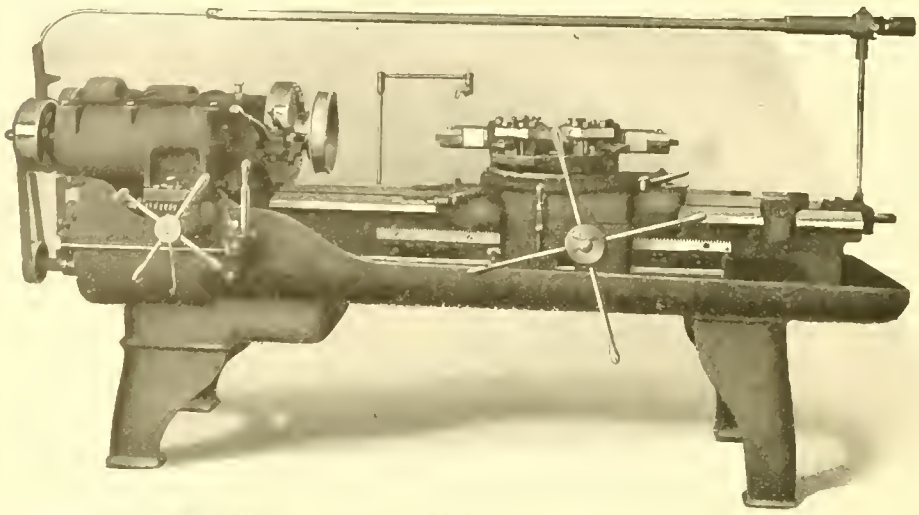
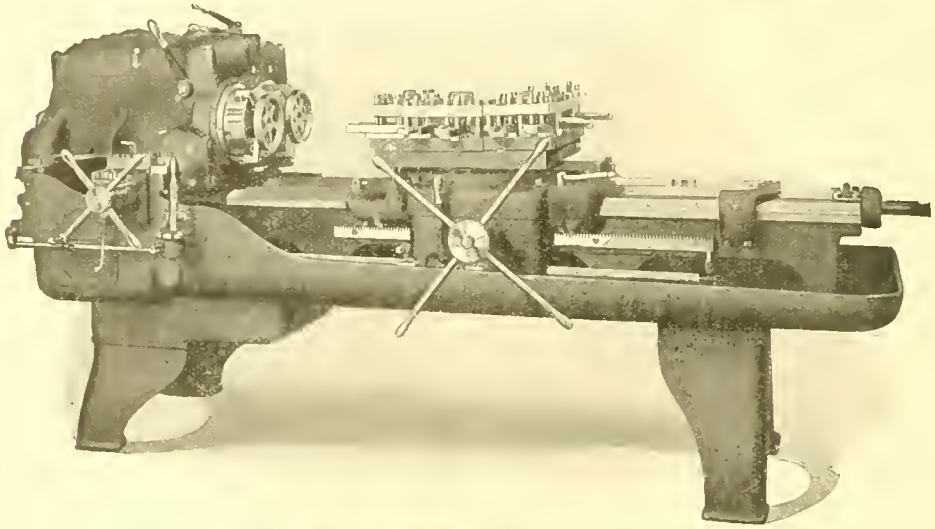
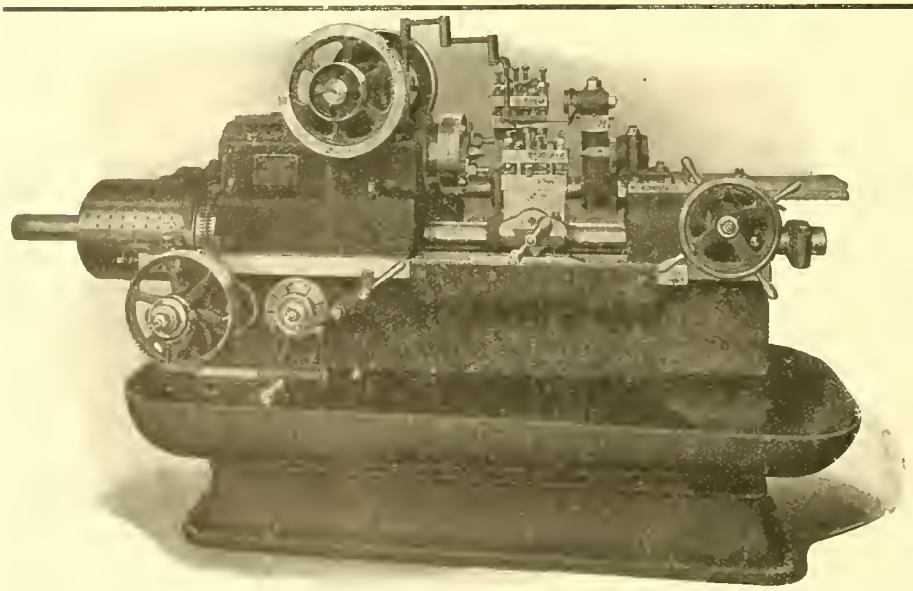


The Hartness Flat Turret Lathe



The Double Spindle Flat Turret Lathe



The Fay Automatic Lathe

LINE OF LATHES

THIS is the regular Flat Turret Lathe which we have built for nearly 25 years.

We have built over 8500 and most all of them—even the "old timers"—are in use today.

The first 2500 were built with fixed heads for bar work exclusively. The rigid control of tools and work in this machine, together with the efficient form of turning tools devised for it, gave it a world-wide reputation for accuracy and productiveness.

In the year 1904, the Cross Sliding Head superseded the Fixed Head. This feature increased its capacity and made it adaptable to both bar and chuck work, and maintained the same rigid control and convenient tool arrangement which gave the machine its reputation on bar work.

It has a rare combination of efficiency and adaptability; though a high production machine, it is versatile and may be changed over to a different line of work at a moment's notice without the necessity of costly special tools and fixtures. It is the most efficient machine in the market for general use; it returns the largest profit on the capital invested.

The Hartness Flat Turret Lathe is made in two sizes. The smaller size handles bar work up to 2¼″ in diameter by 24″ long, and chuck work up to 12″ in diameter. The larger size handles bar work up to 3″ in diameter and 36″ long; or chuck work up to 14″ in diameter with a length varying with the character of the piece.

THIS machine may be used as a regular single-spindle machine, employing the rear spindle only. The corners of the turret are then available, giving practically eight tool positions.

But its principal use is for manufacturing work in large quantities. As a two-spindle machine, with two sets of tools, its output is practically double that of a single machine. It requires only a little longer to set up as compared with the single-spindle machine.

This machine comes into direct competition with the automatic lathe. It has the distinct advantage of permitting the constant variation of speeds and feeds that is necessary for the highest output. This is made possible by having an operator always on the job.

As compared with the multi-spindle automatic machine, it has the further advantage that similar cuts are taken on the two spindles at the same time. The small diameter cut is not slowed down to the speed of the large diameter cut, and the feed for the short cut is not lengthened to that required for the longest cut.

Finally, the Double Spindle Machine brings to quantity manufacture all the advantages of the single spindle on chucking work—the cross-sliding head, the rigid control of work and tool, the simplicity of mechanism and tooling, and adaptability to all sorts and conditions of work. All these advantages are retained; and then they are doubled by being applied simultaneously to two pieces.

The Double Spindle Flat Turret Lathe, when used as a single spindle machine, has capacity for work up to 17″ in diameter. When both spindles are used, a diameter capacity of 10″ is available for each spindle.

THE regular Single Spindle Flat Turret Lathe covers the field for regular machine shop bar and chucking work. The Double Spindle Flat Turret Lathe fills the demand for a manufacturing chucking machine for high production and accurate duplication. There is still a third field filled by an individual machine—the Fay Automatic Lathe.

Many forgings and second-operation work on pieces made from the bar, are best handled on centers. A large range of second-operation work on chucked pieces is best done on arbors. The Fay Automatic Lathe offers the most economical means of performing all this work.

There are many advantages in center point support. For one thing, it offers the quickest possible method for changing work in the machine. The machine is stopped for the shortest possible time. This means also that the operator can handle the maximum number of machines. Again, it offers practically the only method by which a second operation may be performed exactly true with the previous operation. Furthermore, it makes possible an exceedingly simple design of machine. The Fay Lathe is the simplest machine of the automatic lathe type ever built for the market.

The Fay Lathe has an added advantage of being specially adapted to taper turning. Provision for tapers, both slight and steep, is made in the design of the machine, without the use of special attachments. In its field the Fay has no equal.

The capacity of the Fay Lathe is for work up to 14″ in diameter over the bed and 10″ in diameter over the carriage. Its maximum length of feed is 10″.

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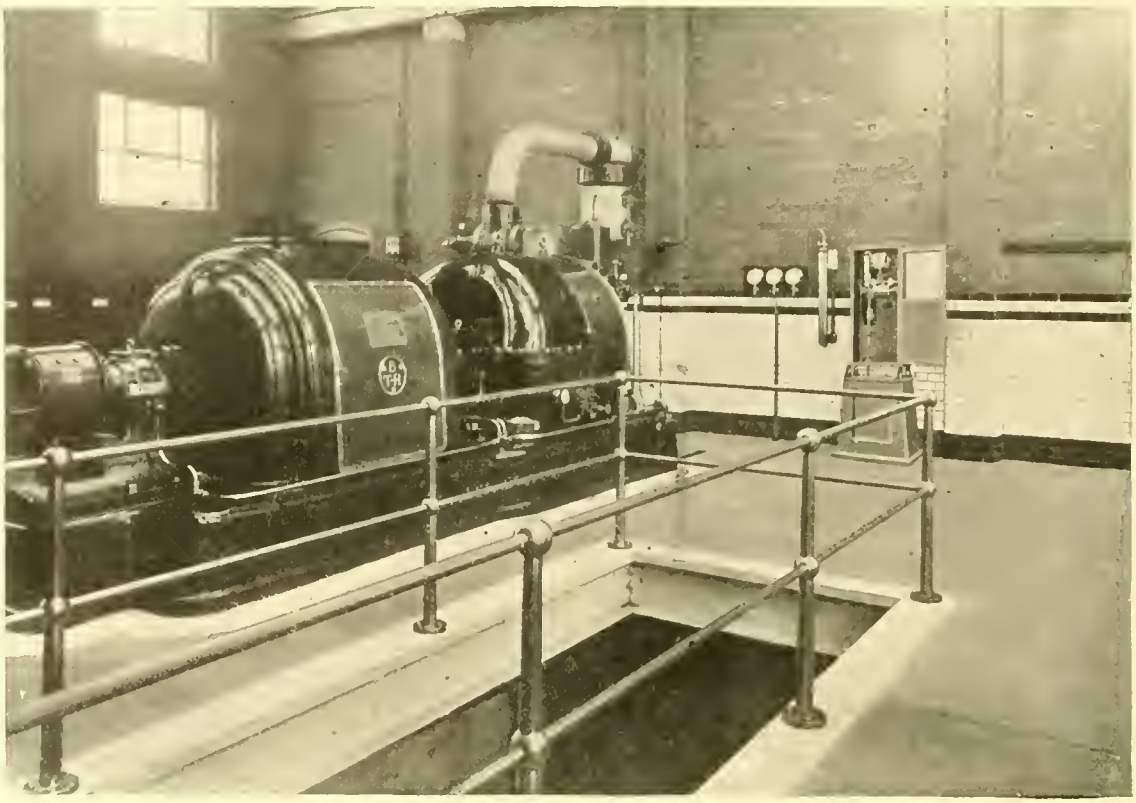

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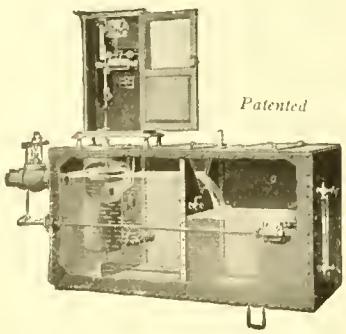

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In addition to the great number of Lea Recording Liquid Meters in use in America, there are as many more distributed all over the civilized world, including South Africa, Australia and India. The above photograph shows the "Lea" Recording Liquid Meter measuring the steam consumption of a British Thomson Houston Turbine Generating Set in the plant of Fred K. Smith & Co., Wire Manufacturers, Salford, Manchester, England.

While the weir tank is on the floor below, note that the "Lea" instrument is on the engine room floor, convenient to the watchful eye of the company's engineer. By consulting the accurate, continuous charted record of the "Lea" Meter the engineer notes immediately the otherwise unsuspected leaks in the engine room, such as eroded or broken turbine blades, too great clearance, or any internal troubles.

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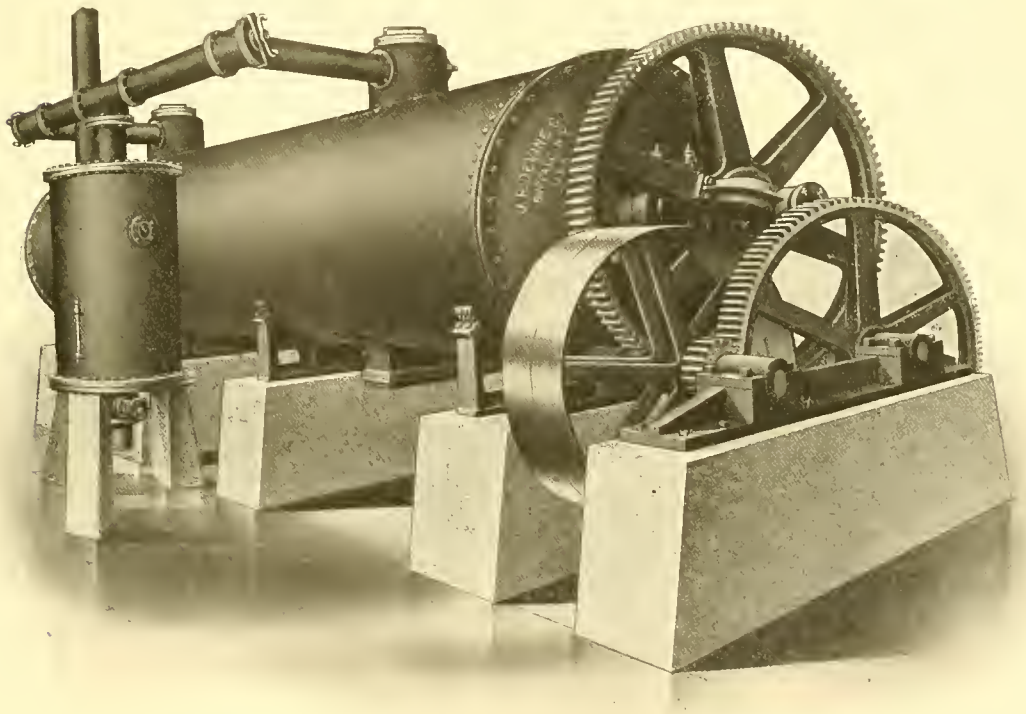

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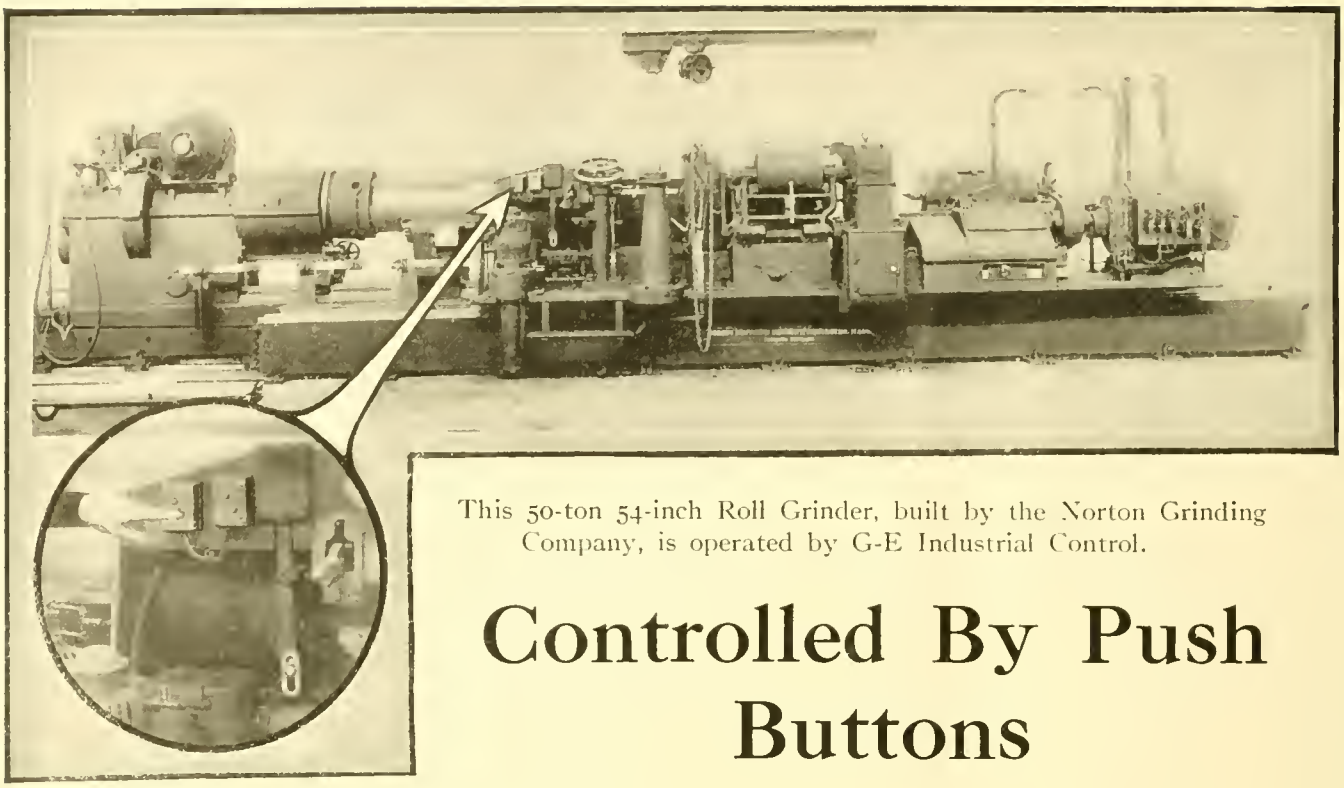

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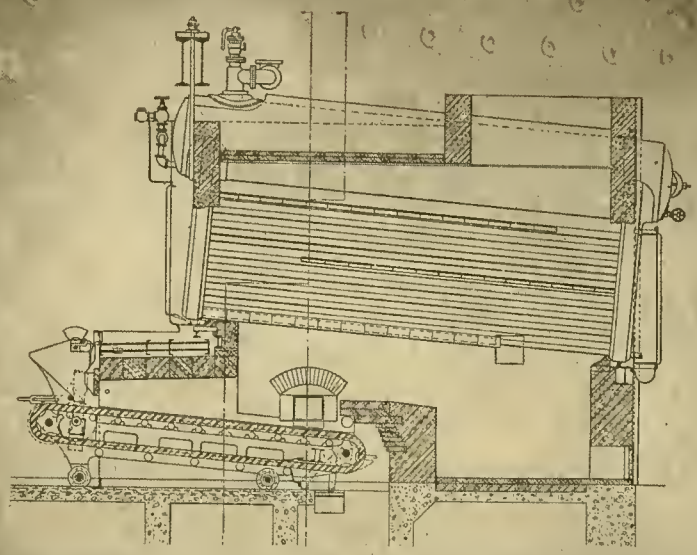
HEINE BOILERS



THIS DRAWING shows a typical large two-pass Heine Boiler set with chain grate stoker operating continuously at loads up to 200% and carrying very high loads for short periods.

The boiler has two horizontal passes for the gases, giving very low flue gas temperature, but with small draft drop through the boiler, because of the minimum number of turns of the gases.

THIS IS THE MOST MODERN BOILER

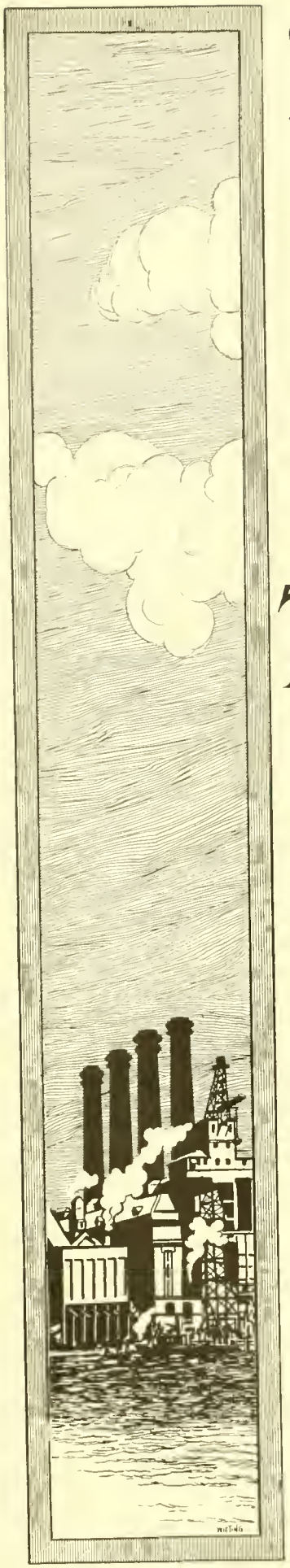
Ask for our pamphlet on Large Boilers.

Numerous tests have demonstrated the superiority of the Heine type horizontal baffling. As compared to the vertical cross baffling, tests by Kreisinger & Ray, showed higher efficiency, lower flue gas temperature and smaller draft loss from furnace to uptake.

These and other tests have also demonstrated the higher furnace efficiency resulting from the horizontal baffle on the lowest row of tubes, which forms the roof of a large combustion chamber and prevents the gases from coming in contact with the comparatively cold boiler surface, until they have been thoroughly mixed and burned.

Heine Safety Boiler Co.

2465 East Marcus Ave. **St. Louis, Mo.**



Civic Pride Means Something Now

Civic pride has ceased to manifest itself merely as Old Home Week oratory, or as equestrian statues in the Public Square. It is becoming a real concrete force for betterment.

Among other things, it is insisting decisively on cleanliness,—cleanliness of streets, cleanliness of atmosphere. And in these days of anti-smoke legislation it is well to remember that the generating station or manufactory equipped with

The Taylor Stoker

is free forever not only from hecklings of smoke inspectors, but also from the stigma inseparably connected with the smoky stack.

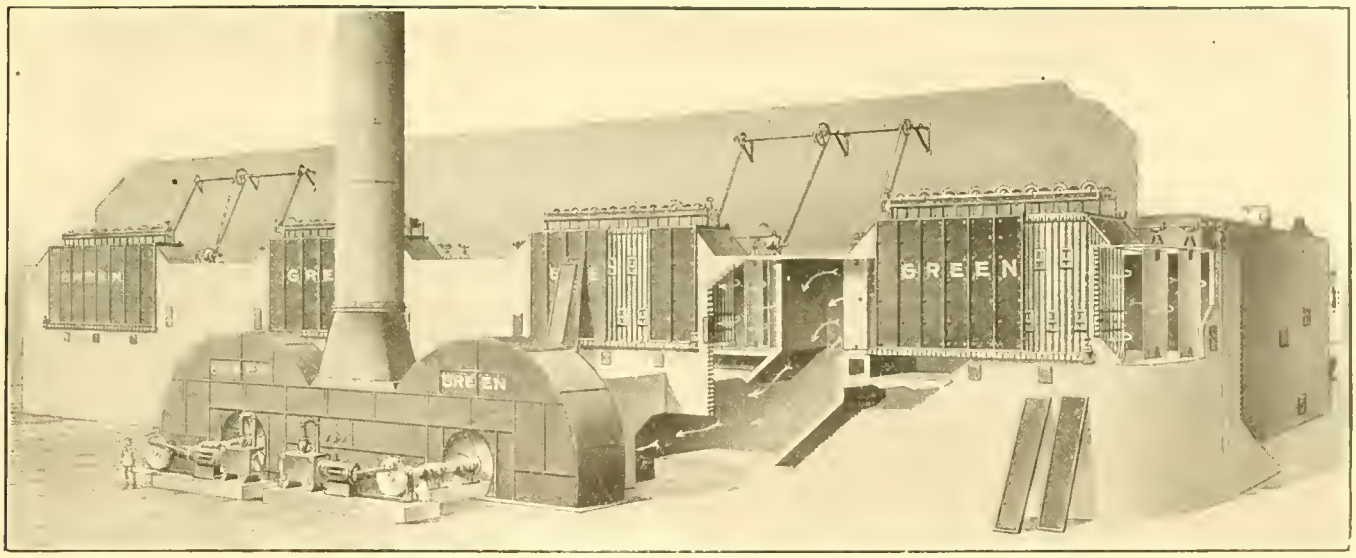
The Engineer who designs a central station today bears a responsibility not only to the owners to produce a plant of economy and flexibility, but to the community to produce a plant of good citizenship—that is, a plant which respects the rights of others, and is a shining leader in the advance toward civic cleanliness.

The smoky-stack plant, announcing to the world that it cannot burn coal without waste, proclaims also its designer's lack of consciousness of responsibility to the community.

The clean-stack TAYLOR STOKER plant, announcing economical combustion, proclaims as well its designer's respect for and sympathy with the battle for civic welfare.....

Which plant is the better reference for the designing engineer?

AMERICAN ENGINEERING COMPANY
PHILADELPHIA



More Steam— Higher Efficiency

WITH more draft you can **burn more coal** upon the grates; 40 lbs. per sq. ft. per hour is not excessive.

With more draft you can **operate the boiler at higher ratings;** 200 to 300% of nominal rating is the standard practice in many large power stations.

With more draft you can arrange your economizer for high gas velocity and high rates of heat transmission, securing a greater return of heat per square foot, and hence **greater profit on the investment.**

With a Green's Economizer you can reduce the temperature of the flue gases from 500 or 600 deg. to 250 or 300 deg. F., effecting **a saving of 12 to 15% of the fuel.**

With a Green's Economizer, the **reduced work of the induced draft fan,** due to the smaller volume of the gases, will more than compensate for the increased resistance due to the economizer.

With a Green's Mechanical Draft Fan and a Green's Economizer, your **steaming capacity may be doubled or even trebled, and the efficiency at the same time improved.**

We would be pleased to give you exact figures and estimates upon receipt of information about your plant, such as the kind of coal you are using (and by the way, we can often cut the coal cost in half by enabling you to burn a cheaper grade), the size and kind of grate; the size and kind of boilers and the present draft arrangements. Accompany your information, if possible, by a sketch showing the location of the apparatus.

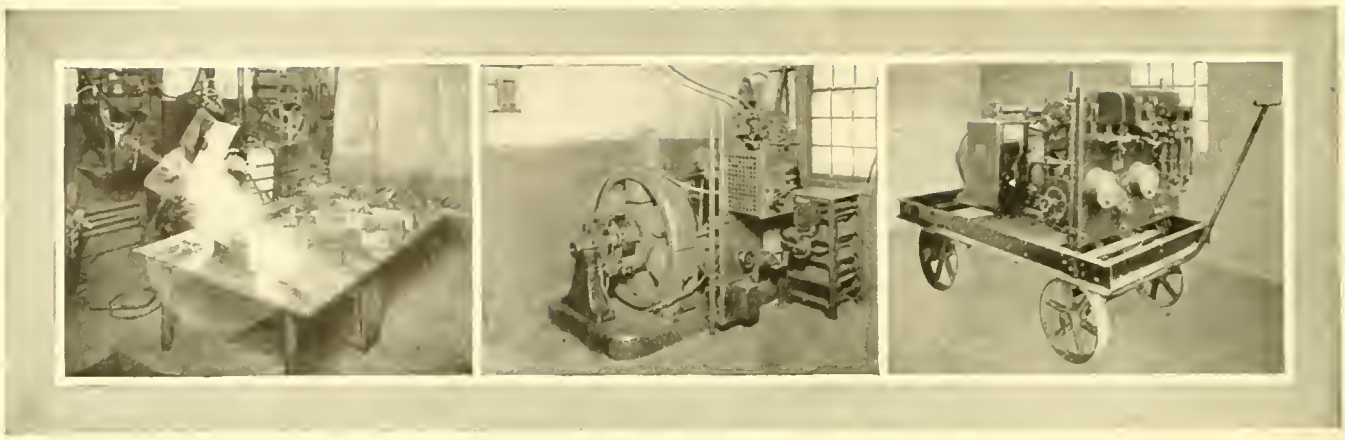
Our booklet M.E.-147 on "The Correct Proportions of Boiler and Economizer Surface," sent upon request.

The Green Fuel Economizer Co.

Matteawan, N. Y.

N w York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, S attle, Salt Lake City, Montreal.

Engineers: Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heater Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines. 382



Economical Welding Outfit Fills Many Needs

The arc welding outfit manufactured by the General Electric Company will fill blow holes in castings, rebuild worn and broken machine parts, remove broken taps and do many things which intimate knowledge of your business will suggest.

Power Transformed—Not Wasted in Resistances

This welding is done on 60 volts or lower. Instead of obtaining the welding voltage from 500, 250 or 125 volt circuits by means of power wasting resistances, this equipment takes power through a motor running from the available power circuit and a generator, which delivers the required current at from 60 to 75 volts. This means a considerable saving in power depending upon the kind of work being done.

Current Automatically Stops With Arc

When arc is broken, the generator does not force current through any power consuming circuit and thus saves the power sometimes wasted in this manner.

Electrode Changed Automatically

While standard sets are not so equipped a device can be furnished that will automatically change from the carbon to the metal electrode with or without change in polarity.

These welding outfits are made in both stationary and portable types. Further details will be sent on request.

General Electric Company

Largest Electrical Manufacturer in the World

General Office, Schenectady, N. Y.

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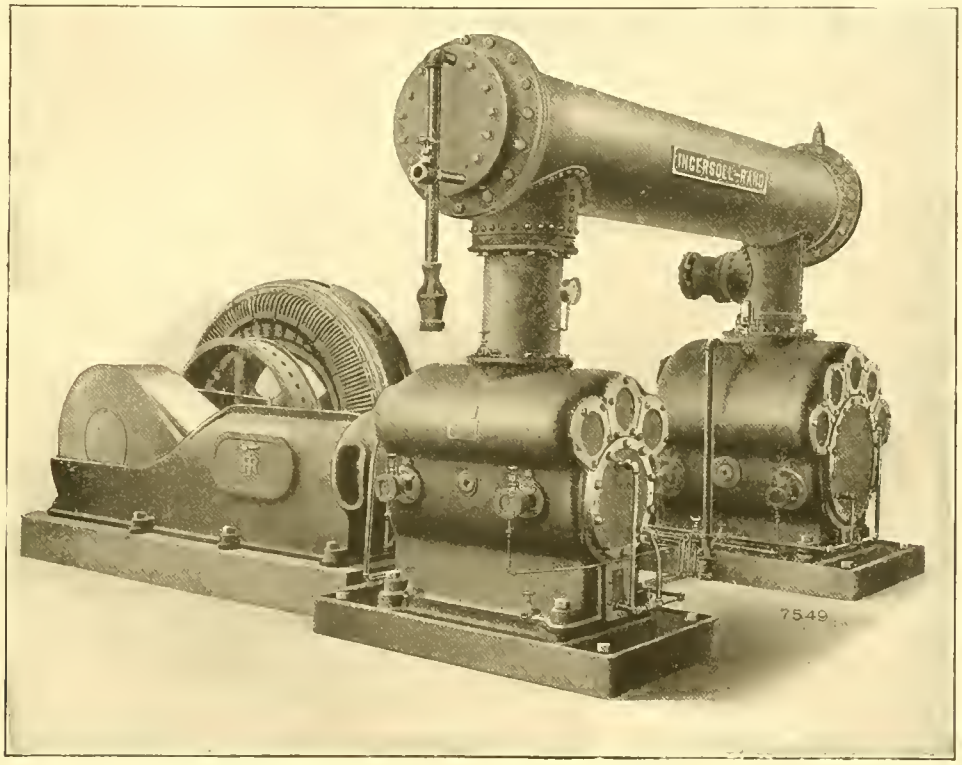
For Texas, Oklahoma and Arizona business refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Lt'd, Toronto, Ont. 4916

"INGERSOLL-ROGLER" AIR COMPRESSORS

Below is shown the Class "PRE," direct connected, electrically driven type. It represents the most advanced design and construction:

"Ingersoll-Rogler" Air Valves, Automatic Flood Lubrication, Automatic Clearance Controller, Wholly Enclosed Construction, Noiseless.



Full information upon request

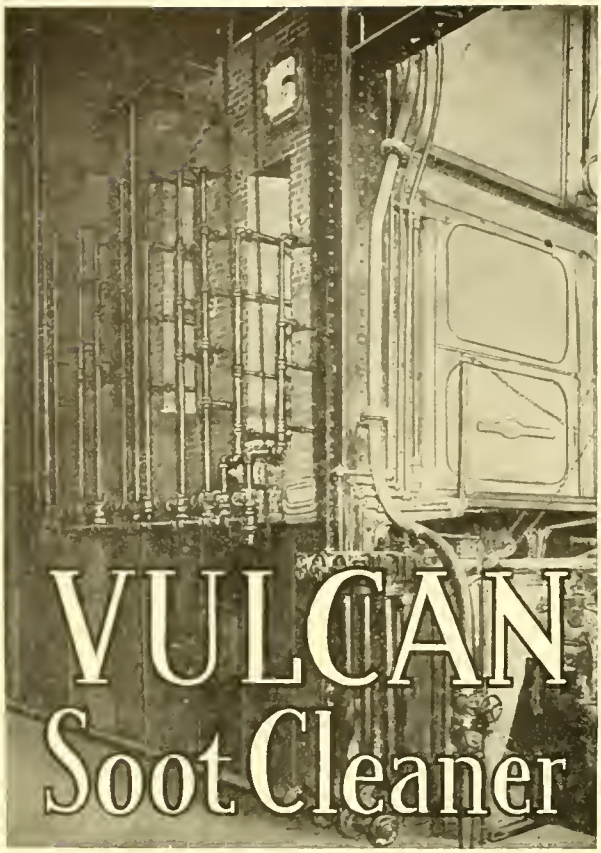
INGERSOLL-RAND COMPANY

New York — Riveters

Offices the World Over — Hoists

London — Pneumatic Drills

7-C.



Applied to

Water Tube Boilers

The principle of the Vulcan is perfect *distribution* of the steam, so directed and controlled as to clean the surface of every tube.

As applied to Water Tube Boilers the Vulcan Cleaner consists essentially of long blow pipes carried across the full width of the boiler. These pipes, which are absolutely essential to complete soot removal, may be either stationary or revolving, and may have perforations at proper intervals or be equipped with special nozzles. Their design and location depends upon many factors, such as size and type of boiler, arrangement of baffling, steam pressure, gas temperature, etc.

Will Not Burn Out

Vulcan Cleaners installed six to eight years ago in Electric Lighting and Traction Power Plants, where conditions are most severe, are still in perfect condition, the maintenance cost being practically nothing.

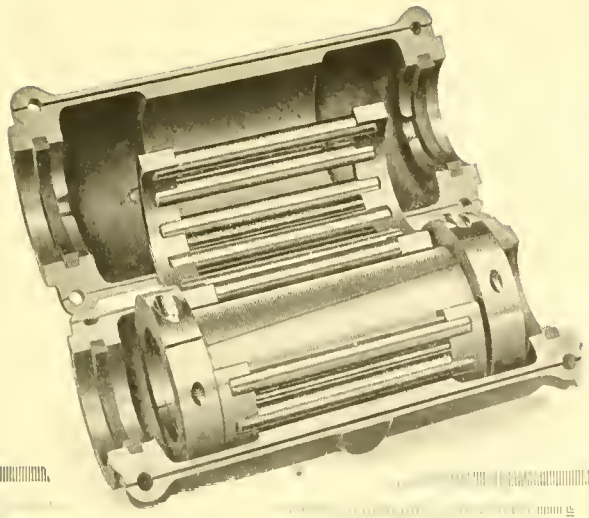
Our new 48-page book, "Economical Steam Production," gives full details of the NEW DESIGNS of the Vulcan as applied to all types of boilers, both water tube and RETURN TUBULAR. Full of interest to Mechanical Engineers. Send for your copy.

G. L. SIMONDS & CO.

Sales Dept. 228 So. La Salle St. CHICAGO

Manufactured by Vulcan Soot Cleaner Co., Du Bois, Pa.

YALE Cylinder Night Latch No. 44 as here illustrated is a convenient, spring latch or a deadlocking night latch just as you *need* it. And when deadlocked it cannot be forced or picked. It will open *only* one way—and that way is with its own key. Your factory has many doors that need the Yale Night Latch—because it is a real Yale lock and that means the *best*.



The *All-Split "Sells"* In Line Shafting

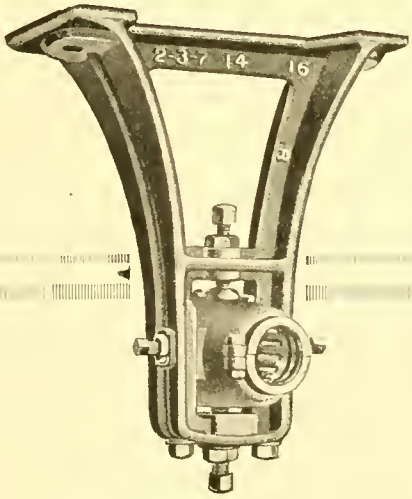
THIS is the bearing that runs in the hanger shown at the bottom of this page. *Every* part of the bearing is split—from the shaft-protecting sleeve, through the collars and the roller structure, to the surrounding box. This makes it equal the babbited bearing in facility of application, but 50 or more per cent. more economical in operation. Exceptional wearing quality places this bearing in a class by itself.

"Sells" Roller Bearings

in their thousands of applications in the largest plants in the country, are demonstrating from year to year, that this saving is continuous, and that years of use show practically no wear whatever. Let us send a Royersford *Engineer* to analyze your conditions, and *show* the manifold economies that "Sells" Roller Bearings bring with them. No obligation whatever.

Also manufacturers "Sells" Commercial Roller Bearings, Power Transmission Machinery, Grinders, Punches and Shears and "Rollerine," the Roller Bearing Lubricant.

Royersford Foundry & Machine Co.
60 N. Fifth Street, Philadelphia



Consult the Cowdrey Machine Works

Concerning Special Machinery

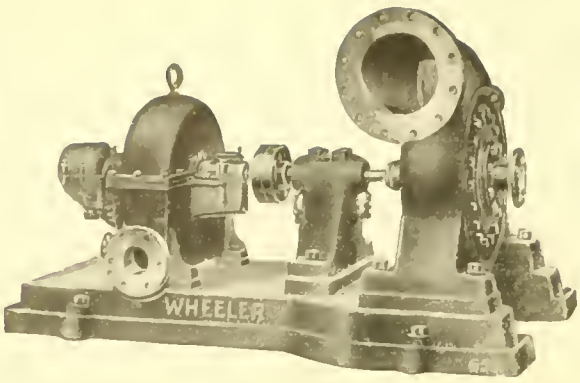
Let us build your special machine, or furnish you with machine work on a contract basis, in our large, up-to-date factory. Our forty years' experience in building special machines for knitting mills, paper making, wood working and nearly every other kind of purpose is sure to be of service to you.

Estimates gladly furnished from blue-prints. Write us to-day

C. H. Cowdrey Machine Works

FITCHBURG, MASS.

Contractors, Builders and Designers of Special Machinery



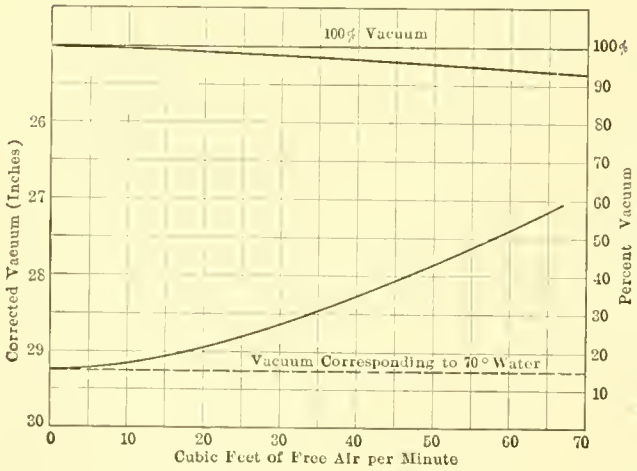
99% Vacuum With The

WHEELER TURBO-AIR PUMP

A WHEELER TURBO-AIR PUMP recently tested showed the following results with hurling water at 70°:

100% vacuum on a closed air suction,
99.7% with 5 cubic feet free air per minute,
99.4% with 10 cubic feet of free air per minute,
And 99% with 20 cubic feet of free air per minute.

CONSIDER THESE FIGURES



The normal air leakage of a large turbine and condenser is only 5 to 10 cubic feet of free air per minute, which the pump will handle at vacuums above 99%.

This means that you can maintain at the turbine exhaust vacuums of 28½ to 29 inches in the Summer and 29½ inches and higher in the Winter, depending upon the amount of circulating water pumped.

If interested in Turbo-Air Pumps, ask for our new Bulletin 111; in surface condensers, ask for our new Bulletin 106-A; in high vacuum jet condensers, Bulletin 107; in cooling towers, Bulletins 104 and 109.

WHEELER

CONDENSER & ENGINEERING COMPANY

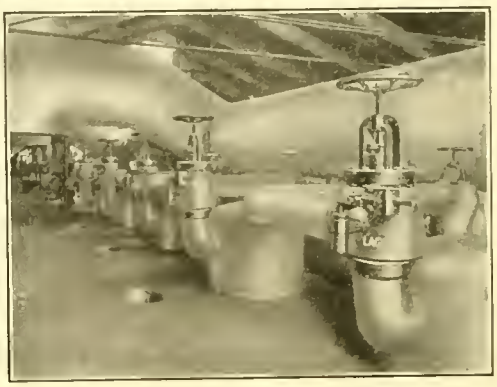
The Pioneer American Condenser Builder

CARTERET, NEW JERSEY 110

SAFETY FIRST

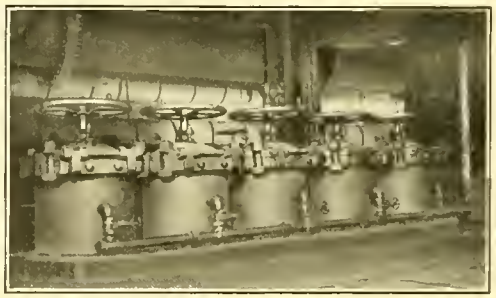
Protection At All Times

IF your plant is equipped with Lagonda Automatic Cut-off Valves and Lagonda Water Strainers.



Automatic Cut-off Valves, Robert Gair Plant Brooklyn, N. Y.

THE Lagonda Automatic Cut-off Valve protects your property and the lives of your employees by preventing the spreading of trouble. It automatically cuts out boilers in which a tube has drawn, blown or other accident has occurred. It does not permit boilers to be thrown into the line until they are at the proper pressure.



30" Five-Basket Strainer, Eastern Traction Co. Terre Haute, Ind.

PROTECTION against drop in efficiency and shut-downs due to disabling of your pumps and condensers is assured if a Lagonda Multiple Water Strainer is installed in your intake line. The leaves, sticks, ice, fish, and other solid matter found in the supply water will be collected in baskets which are easily removed and cleaned without interrupting the flow of water. If you are in accord with this world wide "safety first" movement, send for our instructive and well illustrated bulletins.

The Lagonda Mfg. Co.

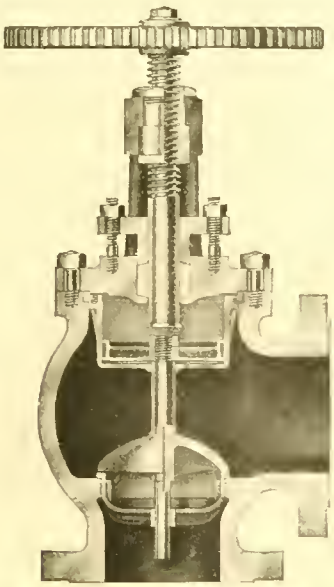
SPRINGFIELD, OHIO

NEW YORK, BOSTON, PHILADELPHIA, ST LOUIS, CHICAGO, DETROIT — FUEL SAVING SPECIALISTS — DALLAS, SAN FRANCISCO, ST PAUL, MONTREAL, LONDON

Makers of Weinland Tube Cleaners, Automatic Cut-off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers (233)

Jenkins Bros.

Automatic Equalizing Stop and Check Valves



These valves are designed to automatically shut off the flow of steam from the header to a boiler in case a tube should burst or other internal rupture occur. They also equalize the pressure between the different boilers in a battery, preventing one boiler from working at a lower pressure than another. As the valves can only be opened by the pressure in the boiler to which they are attached, it is impossible to accidentally turn steam into a boiler which is being cleaned.

The valves are cushioned, to prevent chattering, by an internal dashpot, made entirely of bronze—which eliminates the danger of sticking through corrosion. Care should be taken to install the valves in a vertical position only.

We are prepared to furnish these valves in Extra Heavy Iron Body Pattern, in sizes 4″ to 12″.

Each valve is carefully tested to 800 pounds hydraulic pressure and guaranteed for working steam pressures up to 250 pounds.

For *High Pressure Superheated Steam* up to 800° temperature, we make these valves with bodies and bonnets of Cast Steel having a tensile strength of 70,000 pounds, and other parts of metals which have been found to be best adapted for this kind of service.

All Genuine Jenkins Bros. Valves Have the Diamond Trade Mark— Your Protection

REG. U.S. PAT. OFF. TRADE JENKINS MARK

Jenkins Bros.

Jenkins Bros.

New York, Boston, Philadelphia, Chicago

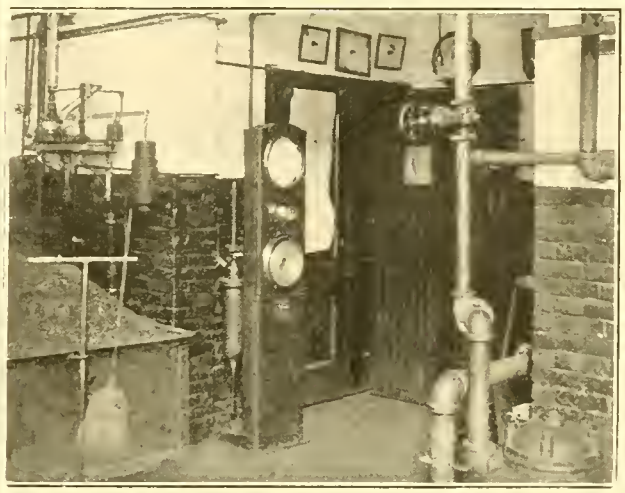
Jenkins Bros., Limited, Montreal, P. Q., London, E. C.

Place the Information where it will do the Most Good

VENTURI BOILER FEED METER

Type M Register-Indicator-Recorder

AT THE ENGINEER'S ELBOW



ON THE BOILER ROOM FLOOR

IN THE ENGINE OR TURBINE ROOM

The Type M Register-Indicator-Recorder of the Venturi Boiler Feed Meter may be located at any distance up to 200 feet from the Venturi Meter Tube.

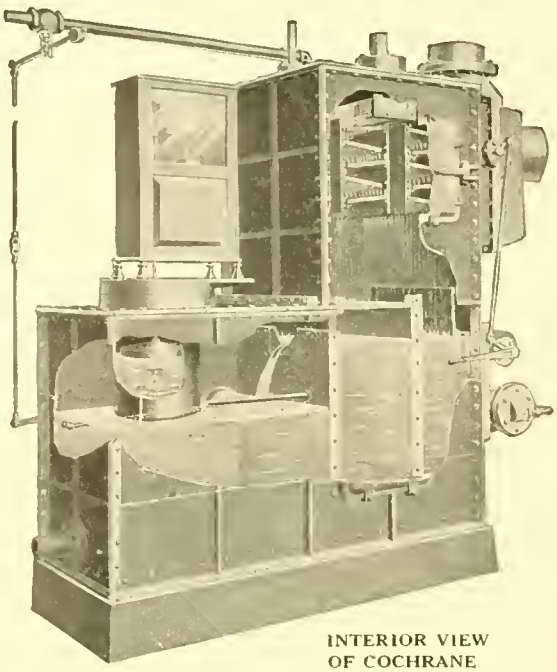
Bulletin No. 68 on Request

Builders' Iron Foundry, Providence, R. I.

"Builders of the Venturi"

New York, Chicago, San Francisco, Portland, Seattle

THE COCHRANE METERING HEATER



INTERIOR VIEW OF COCHRANE METERING HEATER

AFFORDS the means for accurately measuring the water. A great advantage which it possesses over all other metering devices is that it improves economy directly, besides showing you other ways in which the cost of steam production can be lessened, that is, it saves coal by utilizing exhaust steam to heat the boiler feed water.

It is the only meter adapted for measuring hot water in connection with reciprocating boiler feed pumps. Because of the fact that the weir is enclosed within the heater chamber, water at any temperature, as 212° F. or above under back pressure, may be metered without annoyance or loss of heat from the escape of vapor, and the ample storage chambers ahead of and after the weir absorb the fluctuations of the pumps.

Accuracy guaranteed within 1½% of absolute weight.

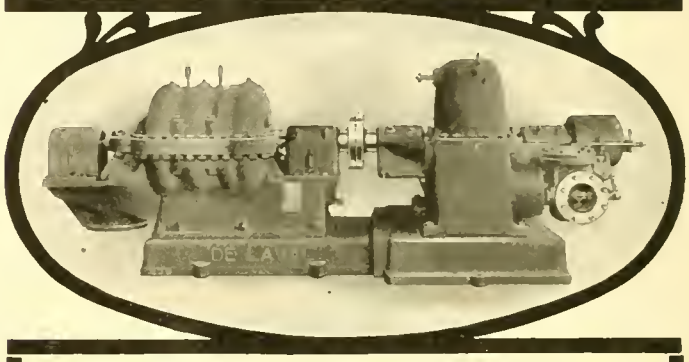
Suggestive facts about boiler plant management are given in our booklet on "Hot Water Meters and Their Practical Application."

HARRISON SAFETY BOILER WORKS

3199 N. 17TH ST.

PHILADELPHIA, PA.

DE LAVAL Steam Turbine Driven Centrifugal BOILER FEED PUMPS



De Laval Class "C" Turbine Driving Three-stage Boiler-feed Pump

De Laval Steam-Turbine-Driven Centrifugal Boiler-Feed Pumps

AMONG many of the advantages of steam-turbine-driven centrifugal boiler feed pumps are:

(1) Extreme simplicity and low cost of maintenance, due to the absence of packings and of sliding surfaces.

(2) Entire absence of shocks, pulsations and irregularity of flow in the pipe lines. This is especially desirable where Venturi or Pitot Tube feed water meters are employed. Records made by such meters in connection with reciprocating pumps are often illegible.

(3) The steam end of the unit is not only more economical than is the steam end of a reciprocating pump, but may be utilized to improve the overall thermodynamic efficiency of the plant, as by (a) running on low-pressure steam from other auxiliaries and exhausting to condenser; (b) utilizing steam from the intermediate receiver of the main engine; (c) running on high-pressure steam and exhausting to heating and drying systems, etc. The turbine may also be of the mixed-flow type, able to operate on either high or low-pressure steam, condensing or non-condensing.

(4) It occupies much less space and is able to handle hot water successfully.

The particular merits of the De Laval Turbine-driven Centrifugal Boiler Feeder include:

(1) Easy access to rotating parts of either pump or turbine by lifting casing cover and without disturbing piping connections.

(2) High efficiency of both pump and turbine.

(3) Extreme simplicity of both pump and turbine. There are no diffusion vanes in the pump and no internal diaphragms in the turbine.

(4) Ready and inexpensive renewability of all wearing parts without disturbing or replacing heavy or expensive parts.

De Laval pumps and turbines are built in all sizes and for all purposes, including water-works pumps, general service pumps, hydraulic pressure pumps, hot water circulating pumps, etc. Also multi-stage turbines for direct connection to high-speed machinery such as alternators and compressors, or through the De Laval Gear to low-speed machinery, such as direct-current generators, rope and belt drive, etc. Single-stage turbines for driving all kinds of machinery through gears and the De Laval velocity-stage turbine especially adapted for driving power plant auxiliaries.

State which subject you are interested in and ask for our general Catalog No. "C58."

DE LAVAL

Steam Turbine Co.

Trenton 111 **New Jersey**

FULTON
Oil and Steam Engines

Are Backed by Our Reputation for Reliability
"Sixty Years of Successful Manufacturing"

We build our machinery complete in our own plant. Long experience has demonstrated the proper materials to be used in our castings and our workmanship is of the highest class.

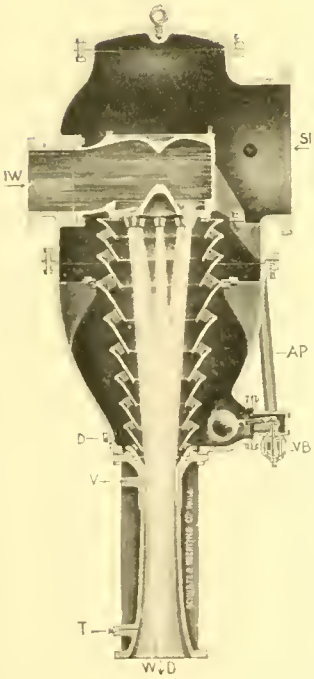
Fulton=Tosi Oil Engines, Diesel Type
Fulton=Corliss, Medium and High Speed Engines

Write for Oil Engine Bulletin "A."

FULTON IRON WORKS

1259 Delaware **ST. LOUIS, MO.**

Our Standard Specifications Guarantee *28" Vacuum and higher with 70° F. Water* Referred to 30 Inch Barometer



The only moving part required for the operation of this condenser is a centrifugal pump, which supplies the water to the condenser at a pressure of 9 lbs. This is the simplest condenser on the market.

Koerting Multi-Jet Condensers

do not require an air pump, as the jets of water discharging from a number of nozzles through throat and tail pipe act at the same time as condenser and air pump.

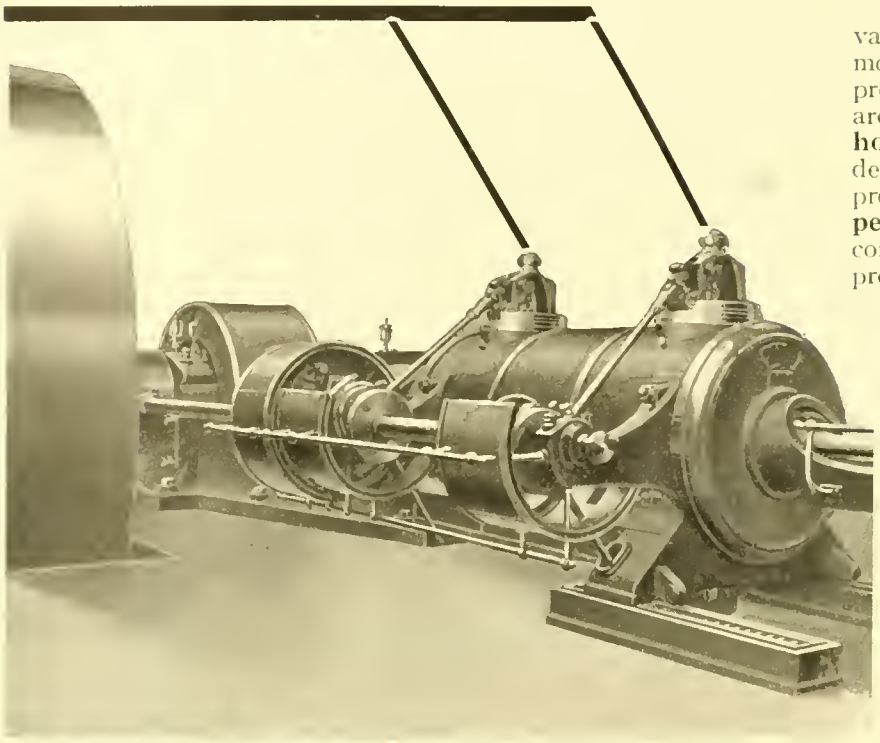
Compared with barometric condenser—our Multi-Jet Condenser has the most desirable advantage that it can be connected *direct* to the exhaust of the turbine, thus saving you considerable money for long exhaust and water pipes, the continuous expense of keeping the many joints tight to prevent air leaks, and the costly erection.

SCHUTTE & KOERTING CO.

1239-57 No. 12th Street **PHILADELPHIA**

New York: 50 Church Street *Cleveland:* New England Building *Pittsburgh:* Keenan Building
Boston: 132 High Street *Chicago:* Security Building *Denver:* 1st Nat. Bank Building

NORDBERG
Poppet Valve Engines



The Nordberg High Speed Poppet Valve Engine, single-cylinder, non-condensing.

THE Nordberg Mfg. Co. has built Poppet Valve Engines for high steam pressures and superheat for over 20 years.

Some of the first engines built are still in operation.

Recently a large number of Poppet valve power engines have been built for modern requirements of high boiler pressures and superheat. Economies are guaranteed of **16 to 22 pounds per horse power hour, non-condensing,** depending upon the boiler pressure, back-pressure and superheat, and **10 pounds per horse power hour,** for compound condensing engines with high boiler pressure, superheat and 26″ vacuum.

Compound engines have high pressure cylinders of the poppet type, and low-pressure cylinders of the Corliss type, this combination giving the highest combined efficiency.

For further information on Nordberg Poppet Valve Engines, send for our new Bulletin 25. Also ask for Bulletins on Corliss and Uniflow Engines.

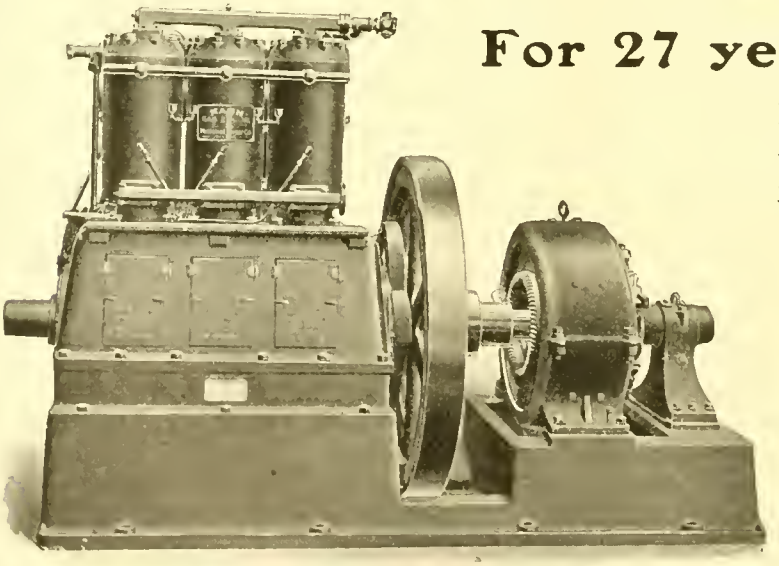
Nordberg Mfg. Co.

Milwaukee, Wisconsin

Manufacturers of High Efficiency Corliss Engines; Uniflow Engines; Poppet Valve Engines; Air Compressors; Blowing Engines; Hoisting Engines; Pumping Engines; and other machinery.

NORDBERG MACHINERY

THE NASH ENGINE



For 27 years the leader in Vertical Gas Engine Design

Specially adapted for

Electric Generation
Water Works
and high grade
Power Plants

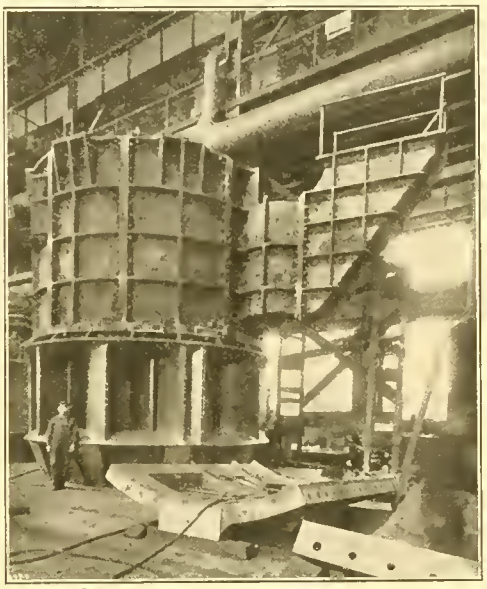
NATIONAL METER COMPANY

CHICAGO NEW YORK BOSTON

I. P. MORRIS COMPANY

PHILADELPHIA, PA.

Specialists in the Design and Construction of High Class, High Power, and High Efficiency Hydraulic Turbines



20,000 H. P. TURBINE
Head 76 feet. Speed 120 R. P. M.
Most powerful Turbines of this Type ever built

Illustration shows one of six turbines designed and built for the Laurentide Company Ltd., Grand Mere, P. Q., Canada. Unit is of the single runner, vertical shaft type, with cast iron pit liner. Volute casing and draft tube are formed in the concrete.

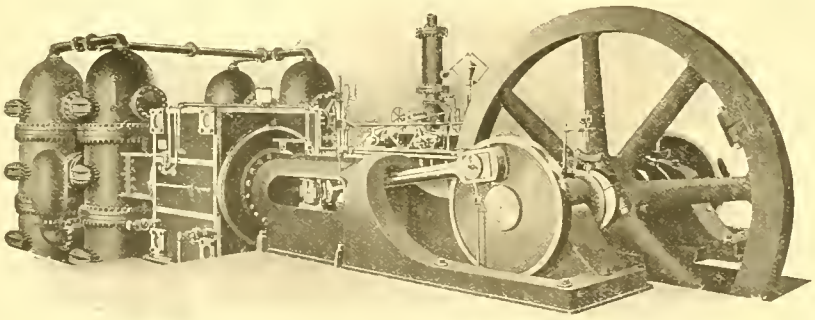
The I. P. Morris Company have built or have under construction turbines of this type aggregating 472,700 horse-power.

Inquiries for turbines requiring special design will be given every attention.

HAMILTON CORLISS

Horizontal Crank and Fly Wheel Pumping Engines

are particularly designed for hard service and long life and the valves are arranged in the annealed steel casting decks in such manner that the flow of water is not deflected in all directions, as is necessarily the case when the bee-hive or cage system is used.

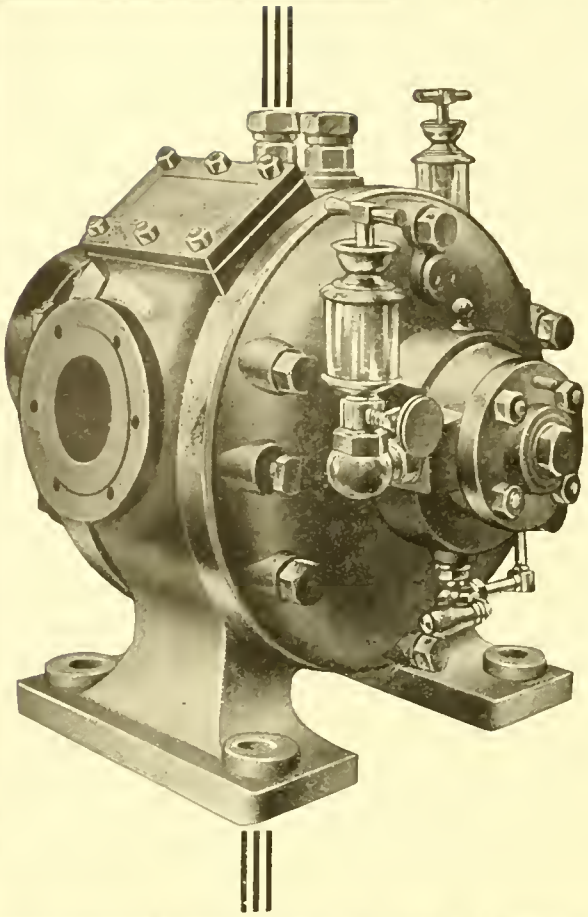


Hamilton Corliss Engines are the most economical steam operated prime movers known and are sold on their operating record.

Send for Bulletin "F"

THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON, OHIO, U. S. A.



For High Vacuum

You can realize the highest possible efficiency in your condensing equipment with the aid of this remarkable

Rotary Air Pump

The operation depends upon a rotary piston and balanced relief valves. No valves are contained on the suction side. Steel shaft runs in high grade ball bearings, resulting in exceedingly low friction losses.

Clearance is practically eliminated, enabling the pump to create a vacuum as high as 0.3" mercury absolute.

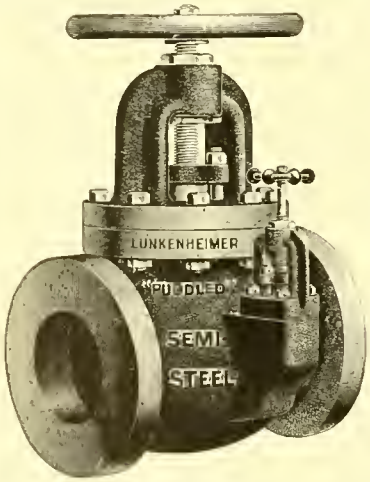
May be mounted on the same shaft with circulating and hot well pumps, the whole forming an ideal compact pump group which may be driven by steam turbine, vertical engine or electric motor.

Used in some of the largest up-to-date plants in conjunction with our Counter Current Rain and Surface Condensers.

Write for catalog and full particulars now

General Condenser Co.

1250 N. 12th St. Philadelphia



LUNKENHEIMER

"PUDDLED" SEMI-STEEL VALVES

The Lunkenheimer line of "Puddled" Semi-steel Valves consists of Globe, Angle, Cross, Check, Gate, Throttle, Non-return Boiler Stop, etc., made in all standard sizes and two combinations as regards the materials used for the trimmings, in order to meet various conditions of superheat. Also made in Cast Steel.

All of the above, together with Lever, Pop Safety, Relief, Blow-off, Screw Down Check Valves, etc., are furnished in Bronze or Iron Body Bronze Mounted.

The large and complete line of Lunkenheimer high grade engineering specialties also includes Water Columns, Gauges and other Boiler Mountings; Whistles and Ground Key Work in great variety; Injectors and Ejectors; Lubricators and Lubricating Devices; Oil Pumps, Oil and Grease Cups; Gasoline Engine Appliances, etc.

Your local dealer can furnish them; if not, write us.

A complete description of the entire line can be had by referring to Lunkenheimer No. 50 Catalogue. Write for a copy.

THE LUNKENHEIMER CO.

"QUALITY"

Largest Manufacturers of High Grade Engineering Specialties in the World

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14-4b

Davis Pressure Regulators Save Steam

No. 2 Regulator with oil dash pot

Made with screwed or flanged ends, standard or extra heavy.

Fit the steam pressure to the job

WHEN your boiler pressure is too high for certain jobs or so low that it slows up others, you lose money in two ways—in the extra coal burned trying to maintain a given pressure and in steam unnecessarily wasted on machines whose required operating pressure is far below boiler pressure. Why not prevent these losses—automatically fit the steam pressure to the job with

Davis Pressure Regulators

Davis Regulators always maintain a constant pressure to the machine, regardless of the demand for steam elsewhere or fluctuations in boiler pressure. And they do this without the toggles, diaphragm, packing or small ports which make some regulators an expensive nuisance.

Let us send you a Davis Regulator for trial. Test it in your own plant. Watch it work. The steady, constant service it gives will surprise you and the resulting economy in steam will show why you should install them throughout your plant.

G. M. Davis Regulator Company

439 Milwaukee Ave., Chicago

New York Boston Pittsburgh San Francisco
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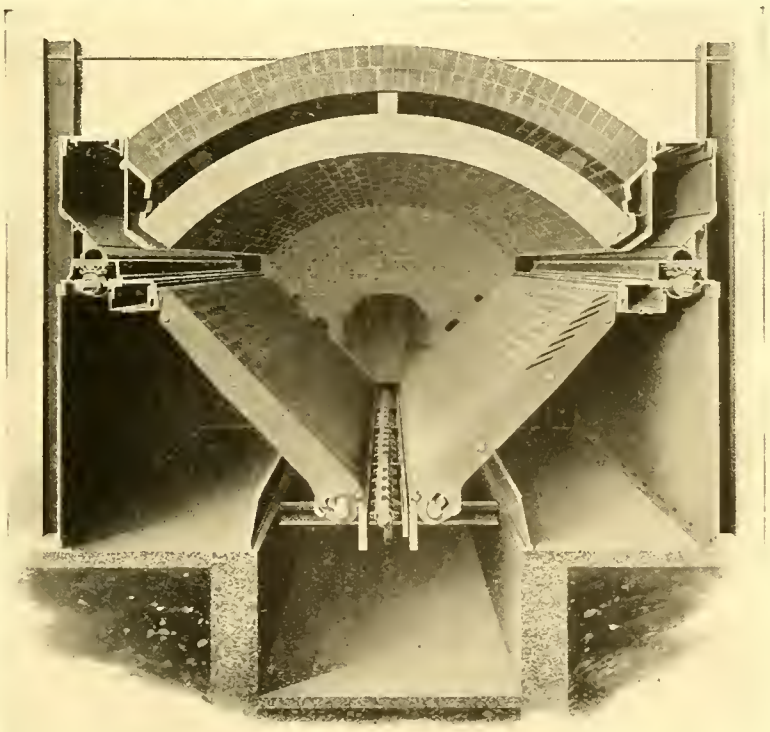
Makers of Valve Specialties Since 1875



TRANSVERSE SECTION—REAR VIEW

Murphy Iron Works

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Murphy

Automatic Smokeless Furnaces

STATISTICS STATE that about ***10%*** of the thirty million dollars worth of coal burned under power boilers each year in the U. S. ***is wasted.***

Murphy Automatic Furnaces burn all grades of bituminous coal without smoke and without waste—and that ***10%*** ***is saved.***

Send for the Catalog

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No Guide Idlers Needed—
Runs True and Even—
No Spillage—

Goodrich
LONGLIFE and MAXECON
CONVEYOR BELTS

reduce tonnage costs

The extreme flexibility found in every Goodrich Conveyor Belt gives you a straight running belt which troughs easily, hugs the pulleys and needs no edge-wearing guide idlers. Goodrich Belts won't ride off and spill the load.

Advise us regarding your installations. We make belts for every purpose.

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Makers of Goodrich Tires and Everything that's Best in Rubber

The B. F. Goodrich Co.
Factories: Akron, Ohio
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There is nothing in Goodrich Advertising that isn't in Goodrich Goods

TRADE MARK JAR REG U.S. PAT OFF

The Best Steel

obtainable might be made into wire which would be too hard and brittle to make a good wire rope.

Or the wire might be of a quality that would stand all tests and yet make a poor rope, because of lack of care and skill in stranding, or because of an improper design.

The good rope, the kind which wears well and gives satisfactory service, is made from wire of uniform quality, stranded together in a workmanlike manner in accordance with designs, planned in the light of experience in manufacture and close study of the operation of wire rope in use.

The rope that bears the above trade mark is known wherever wire rope is used as one which wears well and gives the best service of which wire rope is capable.

Such a reputation is not an accident but the natural result of a thorough appreciation of what must be done to make a good rope, and the necessary facilities for doing it.

John A. Roebling's Sons Co., Trenton, N. J.

Reduce Costs and Promote Factory Efficiency

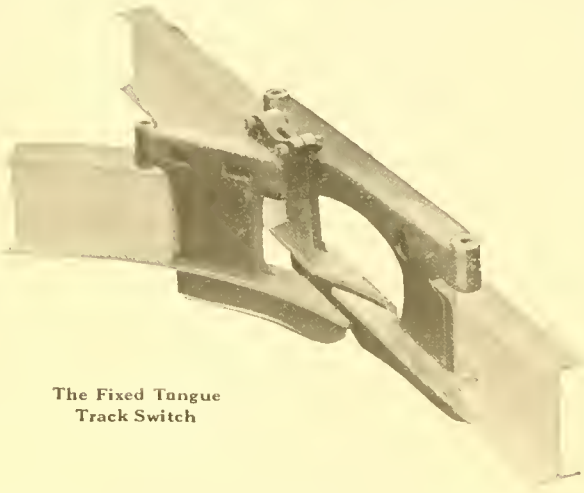
Shaw F. T. Electric Monorail System

The Shaw "F-T" Electric Monorail System is DIFFERENT.

The term "F-T" signifies the **FIXED TONGUE** in the track switch—no moving part—nothing to set—no open ends.

These distinctive features of the Shaw Monorail System establish the **SAFETY** and **EFFICIENCY** of the overhead monorail for Factory Transportation.

SAFETY—Owing to the absence of any open ends in the track system, derailments are impossible and no "safety appliances" are required.



The Fixed Tongue Track Switch

EFFICIENCY—No time is lost at the switches—the Shaw Monorail Hoist is "dirigible" and runs through the switches without stopping—the operator in the cab controls the route as well as the hoisting and travel motions.

Heretofore the weak point in the Overhead Monorail has been the track switch, but with the Shaw System the Track Switch is an advantage instead of a draw-back.

The Shaw "F-T" Monorail Hoist is built with the ordinary single lift or with double lift for handling long material; also for Grab Bucket operation.

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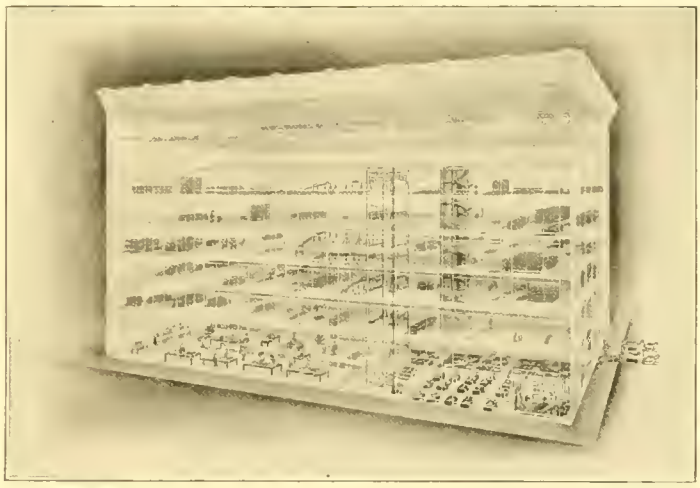
Reducing the Pay-Roll—Improving the Product—Increasing the Capacity—

are the three most important accomplishments of a Conveyer System.

In these days of manufacturing retrenchment, architects and engineers are alive to the necessity of providing the best and simplest means for reducing time and labor in manufacturing processes. Development in gravity and power conveying devices have attracted wide and interested attention, and all promoters of industrial projects are giving the subject thorough investigation.

Be prepared to specify the best types of mechanical handling machinery by securing literature illustrating and describing the Mathews line of Standard Equipment—the oldest and best-known in America.



Complete System of Mathews Power and Gravity Conveyers in One of the Largest Shoe Factories in the World

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We have branch offices in all leading American cities with competent engineers in charge. Personal assistance given to architects and engineers in working out handling systems for their clients. We make no charge for this service.

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Cut out this coupon, attach it to your letter head and we will mail our full set of catalogs and bulletins illustrating and describing the Mathews line of Standard Equipment, consisting of Gravity Conveyers, Automatic Elevators, Gravity Roller Spirals, Gravity Spiral Chutes, etc. Sooner or later you will have use for the information given in our literature.

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"Patented"

Design used in diameters of 3", 4" and 5".

"AMERICAN" STEEL SPLIT PULLEYS

(Made in diameters 3" to 60" inclusive)

Their superior belt grip and strength, combined with lightness, have made them the most widely used metal pulley in this country.

Dealers Everywhere

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Design used in diameters 44" to 60" inclusive with faces wider than 16".

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Miniature Precision Instruments for Direct Current

A new group of very small Indicating Instruments

COMPACT — ACCURATE — DURABLE — BEAUTIFUL

MODEL 280, Single Range Portable Voltmeter. (One-quarter Size.)

MODEL 280, Triple Range Portable Volt-Ammeter. (One-quarter Size.)

PORTABLE

Voltmeters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters, are supplied in single, double and triple ranges.

The triple range volt-ammeter comprising six instruments in one. This group also includes BATTERY TESTERS

SWITCHBOARD

Voltmeters Volt-Ammeters Ammeters Mil-Ammeters

MODEL 267, Switchboard Ammeter. (One-quarter Size)

MODEL 268, Switchboard Volt-Ammeter. Reads Amperes. Press Button for Volts. (One-quarter Size.)

This new line of instruments represents the latest development of the pivoted moving coil, permanent magnet type for low ranges.

The refinement of design and mechanical work in them has been carried to a degree which would appear to be almost impossible of accomplishment, if the results were not evident in the instruments themselves.

They embody characteristics which have made the well known Weston Standards famous throughout the world.

They are accurate, dead beat and extremely sensitive.

They may be left continuously in circuit at full load without injury and are shielded against the external electrical and magnetic influences of other apparatus in their vicinity.

They are substantially constructed and may be safely sent long distances through the mails and will withstand an extraordinary amount of vibration without injury.

They have the longest scale ever provided in instruments with equal length of pointer.

Each model has been thoroughly tested under the most severe conditions of service and in experiments extending over more than one year.

The portable instruments may be conveniently carried in the coat pocket.

The prices have been established upon so low a scale that any one may possess one or more of these remarkable instruments at moderate cost.

If you cannot obtain the instruments desired from your dealer, write us.

The several models and ranges offer a selection from over 300 different combinations, listed in Bulletin No. 8. Will be mailed upon request.

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Badt-Westburg Elec. Co., 832 Monadnock block, Chicago, Ill.

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Geo. H. Moseman, 176 Federal St., Boston, Mass.

Milton Mill, 915 Olive St., St. Louis, Mo.

B. K. Sweeney Electrical Co., 2910 Huron St., Denver, Colo.

Frank E. Smith, 682 Mission St., San Francisco, Cal.

S. C. Dinsmore, 1933 Dime Bank Bldg., Detroit, Mich

Walter P. Ambos Co., 1729 East 12th St., Cleveland, Ohio.

A. H. Winter Joyner, Ltd., 76 Bay St., Toronto, Canada.

Weston Instrument Co., Ltd., Geneststrasse 5, Schoneberg, Berlin, Germany.

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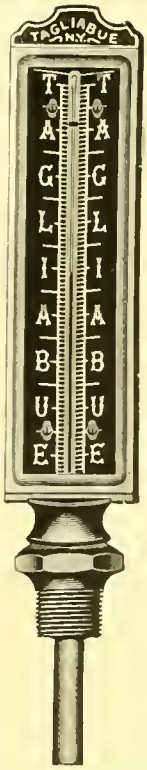

Do You Know Your Temperatures?

If temperature enters into your manufacturing processes, you should use

TAGLIABUE

Hohmann-type

THERMOMETERS

They will always indicate your temperatures accurately; they are built to withstand the most severe strains; they are made to fit your special purpose. Made with any scale, of special stem materials, and with particular connections for particular applications.

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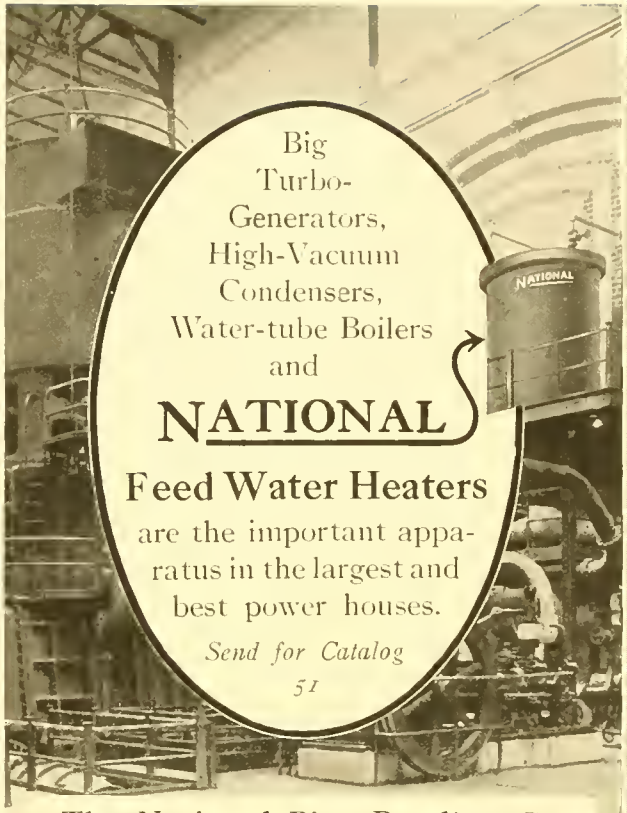

Big Turbo-Generators, High-Vacuum Condensers, Water-tube Boilers and

NATIONAL

Feed Water Heaters

are the important apparatus in the largest and best power houses.

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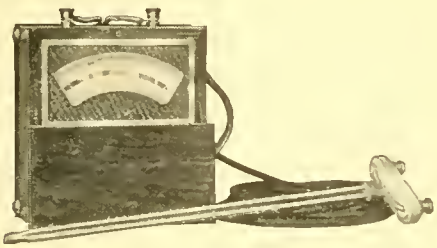
The National Pipe Bending Co.

New Haven, Conn.

Brown Pyrometers



Meet every requirement in the measurement of temperatures up to 3600° or as low as —200°. Brown High Resistance Pyrometers are unaffected by the length of wire connecting the thermo-couple and indicator. Our 56-page Catalogue describes other advantageous features.

THE BROWN INSTRUMENT CO.

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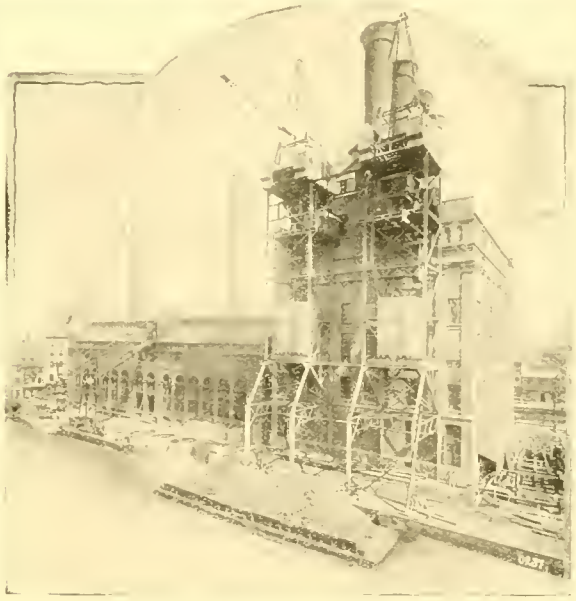

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TWO ELECTRICALLY OPERATED

"HUNT" STEEPLE TOWERS

Height of Towers - - - 183 feet
Height load is hoisted - - 151 feet

Installed fourteen years ago and

Still Thoroughly Efficient

C. W. HUNT CO., Inc., West New Brighton, N. Y., U. S. A.

45 Broadway, New York City Fisher Building, Chicago
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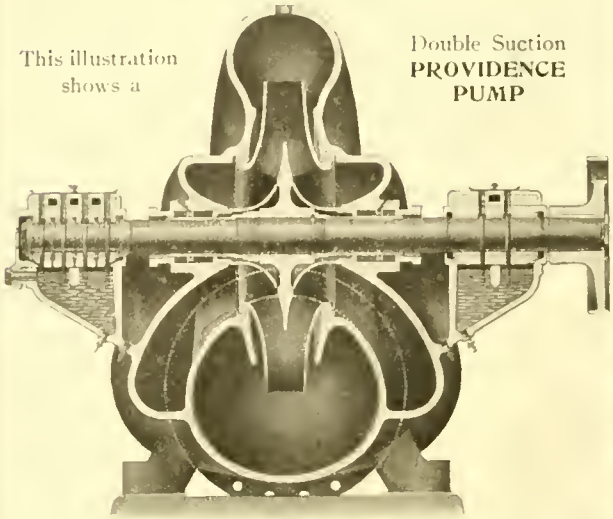
PROVIDENCE PUMPS

This illustration shows a

Double Suction PROVIDENCE PUMP



are built for all purposes in capacities of 100 to 100,000 gallons per minute.

Double Suction Pumps for moderate heads.

Stage Pumps for greater heads or pressures.

Send for Bulletin

PROVIDENCE ENGINEERING WORKS

Providence, Rhode Island

C. H. Wheeler Condensers

We guarantee our apparatus to maintain a vacuum as close to absolute as is commercially possible, and with the lowest operating and maintenance cost.

The C. H. WHEELER "High Efficiency" System of Steam Auxiliaries includes:

C. H. WHEELER High Transmission Surface Condensers.
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C. H. WHEELER-PRATT "ROTREX" Patent Vacuum Pumps.
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have gained the utmost confidence of the engineer who is looking for lubricating efficiency, and who understands the possibility of reducing power costs by using the oil most suited to the purpose.

The Texaco Line includes an oil for every purpose—your purpose too.

We have been able to observe Texaco Lubricants under so many conditions, and have invariably seen them operate to save power, fuel, bearing wear and repair expense, that we can definitely promise you a saving in your particular field. It will pay you to investigate. We solicit inquiries.

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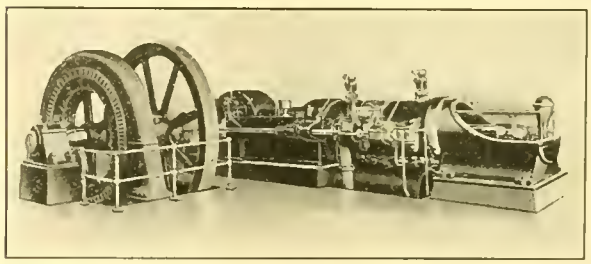
OIL-BURNING ENGINE



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FOR

Simplicity, Efficiency and Durability

STANDARD SIZES 300 to 600 B. H. P.

Operates on the Diesel principle with a guaranteed fuel consumption not in excess of 7½ gallons of crude or refuse oil per 100 B. H. P. hours.

Let us send you descriptive matter covering details of construction and operation.

HERBERT B. RUST, Sales Agent

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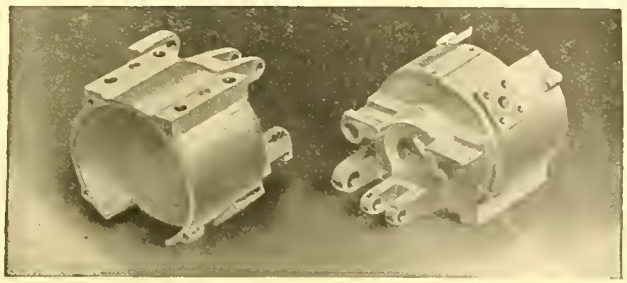
THE BROWN ENGINE CO., Fitchburg, Mass.



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(92% Aluminum and 8% Copper)

offer unusual opportunity to reduce production costs

We use No. 12 aluminum alloy, which is pure aluminum hardened with 8% of copper. This is generally conceded to be the toughest and strongest aluminum alloy known and is made even more serviceable by our process of die-casting.

Dimensions are accurate to within .001" to .005", according to size and design.

Each part submitted to us receives the careful consideration of our engineering department.

We assume full responsibility for the successful production of all parts undertaken by us and we get the details right the first time.

Further information and samples for inspection and test will gladly be furnished on request.

DOEHLER DIE-CASTING CO.

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Western Plant: E. Woodruff & N. 12th Sts., Toledo, Ohio.

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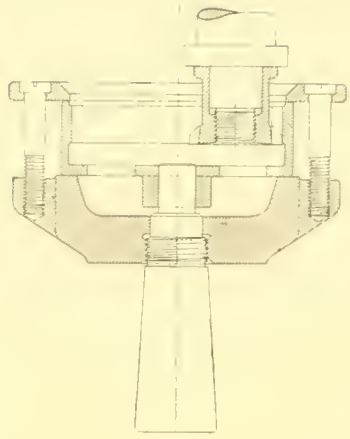

SMALL INTERNAL GEARS of the type shown here are readily planed on the Gear Shaper, using what we term a hub cutter. Are you equipped for satisfactorily cutting internal and shoulder gears?

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23 Pearl Street, Springfield, Vermont, U. S. A.

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CYCLOMETERS
For Bicycles and Motorcycles, to Register the Distance Traveled.

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For Automobiles and Horse-Drawn Vehicles, to Measure Distance Traveled.

COUNTERS
To Register Revolutions or Reciprocating Movements. Twenty-five Styles.

SPEED COUNTERS
For Finding the Revolutions per minute made by a Shaft or Any other Revolving Part.

TACHODOMETERS
To Indicate the Speed and Record the Distance Traveled, both Trip and Total. For use on Automobiles, Locomotives and Electric Railway Cars.

TACHOMETERS
To Indicate Speed in Revolutions per Minute of Shafts, Generators, Motors, etc.

FINE DIE CASTINGS
Where Large Numbers of Absolutely Uniform Small Parts are Required.

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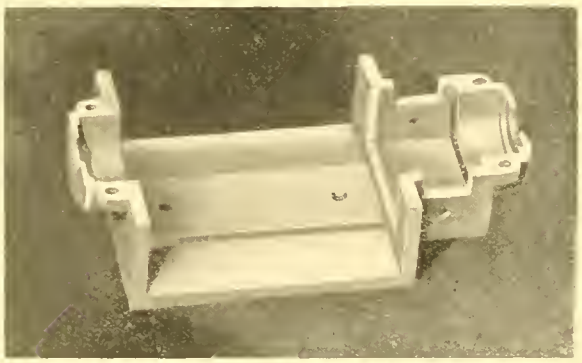


Only High Grade Die Work Can Insure Accurate Castings

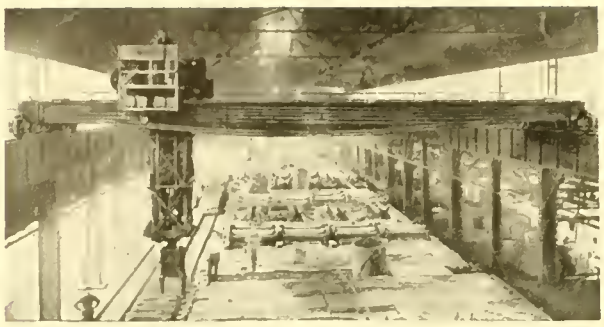
No die-cast part can be more accurate than the die in which it is produced.

Franklin dies are the result of twenty years' experience in die construction. We were the pioneers in the field. Our dies, coupled with our experience in perfecting die-casting alloys, have made Franklin die-cast parts a standard for quality.

If your requirements are exacting, it will pay you to read our Booklet "D."

Franklin Manufacturing Company

404 South Geddes Street Syracuse, N. Y.



Another

ALLIANCE CRANE Application

The Alliance Low Type Stiff Legged Soaking Pit Crane shown above is designed to meet conditions where only a limited head room is available. It is exceedingly fast, and, like all Alliance cranes, is built for highest efficiency. May we describe it in detail for you?

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ENGINEERS AND BUILDERS

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Power Transmission Appliances

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Mechanical, Economical, Efficient

Friction Clutch Pulleys	Hangers and Pillow Blocks
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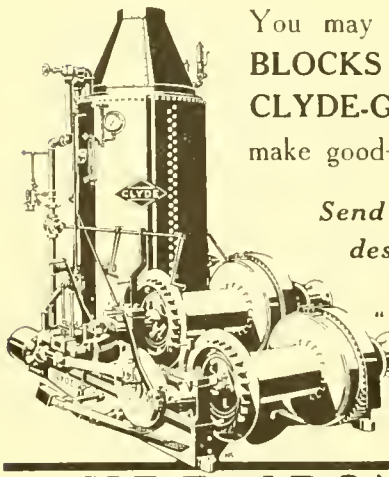
It doesn't pay to economise on equipment for a derrick

What is gained in first cost on cheap blocks, etc., is lost in working efficiency, since the capacity of a derrick is no greater than that of the tackle used with it.



You may pay a little more for **BLOCKS and SHEAVES of CLYDE-GRADE** but they will make good—or we will!

Send for Bulletin 33 describing them

"You'll find a Repeat-Order built into every Hoist of Clyde-Grade"

CLYDE IRON WORKS
MANUFACTURERS of CLYDE-GRADE HOISTING MACHINERY
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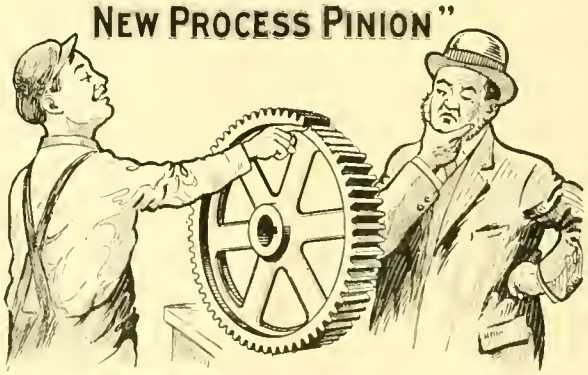

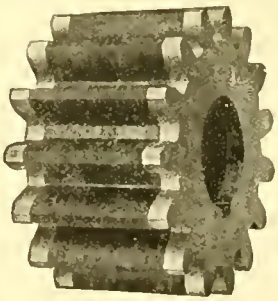

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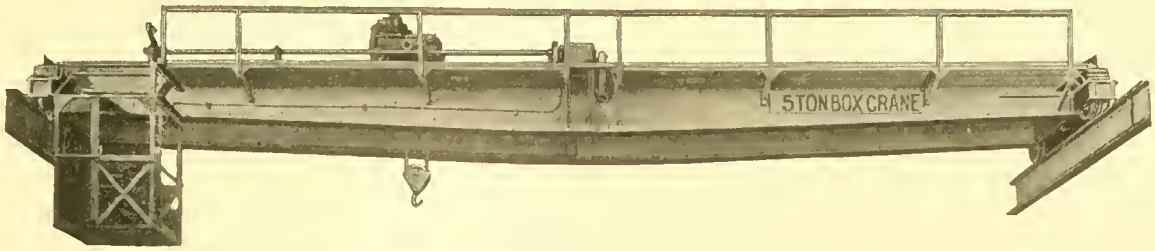

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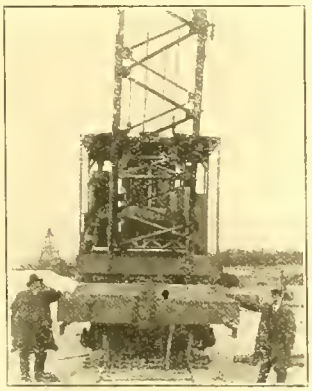

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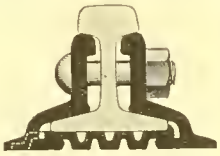

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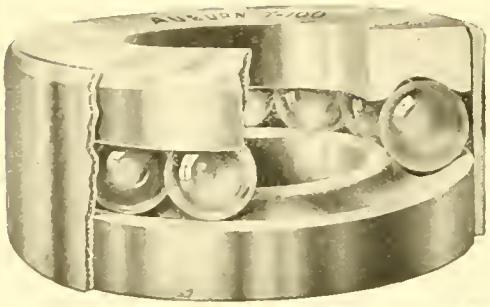

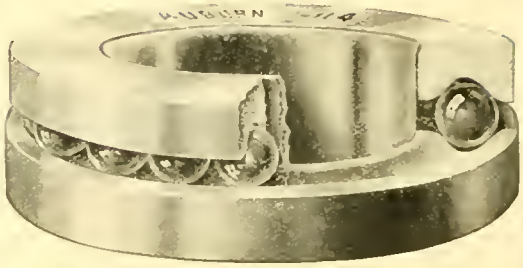

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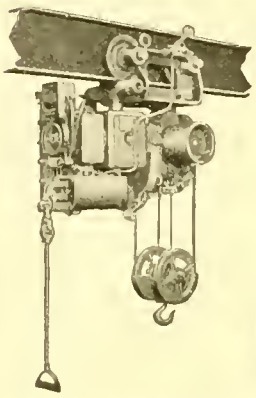

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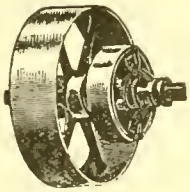

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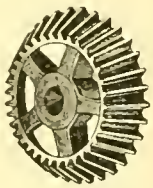

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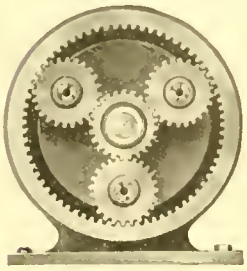

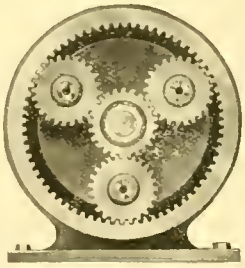

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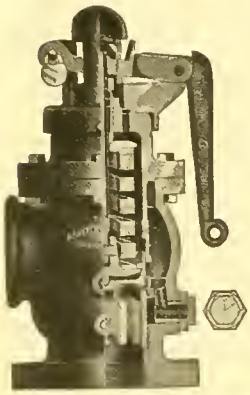

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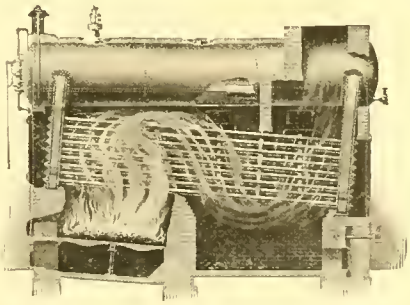

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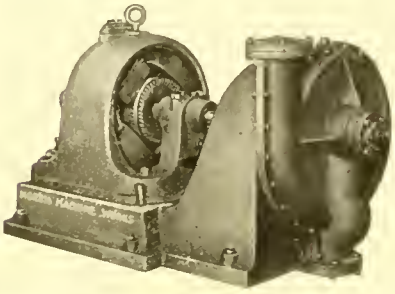

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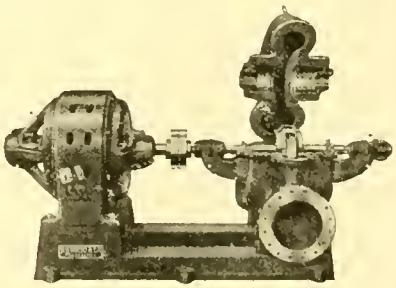

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Steam Traps

Separators

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See pages 84, 85 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Telephone: 6097 Franklin

Heat and Cold Insulating Materials. Headquarters for 85% Magnesia Asbestos and Brine Pipe Coverings, Asbestos Products, etc.

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See pages 86, 87 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves

Blow-off Valves

Fire Hydrants

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Manufacturers of high-grade engineering specialties, comprising Brass and Iron Valves, Whistles, Cocks, Gauges, Injectors, Lubricators, Oil Pumps, Oil and Grease Cups, etc., adapted to the requirements of all classes of machinery.

See pages 88–93 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves

Injectors

Lubricators Etc.

MOREHEAD MANUFACTURING CO.

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Return, Non-Return, Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

See pages 112, 113 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Builders of The Murphy Automatic Furnace. The best Automatic Furnace that thirty years practical experience can produce.

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National Feed-Water Heaters, National Storage Heaters, National Direct Contact Heaters and Purifiers, National Steam and Oil Separators. Coils and Bends of Iron, Brass and Copper Pipe.

See pages 62, 63 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Feed-Water Heaters and Purifiers

Separators

PAPERS PUBLISHED BY A. S. M. E.

No. 1085. Performance of a Superheater: A. Bement, price $0.10; No. 1070. A Twist Drill Dynamometer: H. P. Fairfield, price $0.10; No. 921. The Bursting of Small Cast Iron Fly-Wheels: C. H. Benjamin, price $0.20; No. 1144. Balancing of Pumping Engines: A. F. Nagle, price $0.10.

Papers on Power Plant Specialties

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See page 91 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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See page 131 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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POWER SPECIALTY CO.

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Manufacturers of Brass, Iron and Steel Valves, Fire Hydrants, Asbestos Packed Cocks.

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Designers and Manufacturers of Steam Specialties and Power Plant Appliances: Closed Feed Water Heaters, Open Feed Water Heaters, Hot Water Generators-Convertors, Laundry Heaters, Live Steam and Water Mixers, Exhaust Heads, Oil Extractors, Oil Filters, Compound Feeders, Garbage and Refuse Burners, Tanks.

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Manufacturers of Instruments for Indicating, Recording and Controlling Temperature and Pressure. Thermometers; Automatic Controllers; Gages; Oil Testing Instruments; Engineers' Testing Sets, Pyrometers, Barometers, Hygrometers, Hydrometers, etc.

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Lubricating Oils for Power Plants, Central Stations, Machine Shops, Foundries and all general purposes. All classes of Petroleum Products of the highest quality.

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Condensers

Pumps

Cooling Towers

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Manufacturers of High Vacuum Apparatus, Condensers, Air Pumps, Feed-Water Heaters, Water Cooling Towers, Boiler Feed and Pressure Pumps.

See page 65 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Condensers

Cooling Towers

Feed-Water Heaters

YARNALL-WARING CO.

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Manufacturers of the "Lea" V-Notch Recording Meter, Simplex Seatless Blow-off Valve and the Simplex Pipe-Joint Clamp.

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Water Meters

Blow-off Valves

Pipe-Joint Clamps

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THE AMERICAN PULLEY CO.

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The American Pulley. The first all steel parting belt pulley made. Now sold in larger quantities than any one make of pulley. No key, no set screw, no slip; light, true and amply strong for double belts. 180 stocks carried in the United States.

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Auburn Four Point Contact Cone Principle Ball Thrust Bearings, Auburn Special Ball Thrust Bearings, Auburn Steel, Brass and Bronze Balls, Solid and Hollow.

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Manufacturers of Shafting, Pulleys, Hangers, etc., for Transmission of Power.

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Pulleys

Hangers

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Everything for the Mechanical Transmission of Power, Elevating and Conveying; and Water Softeners. Write for "Power Transmission Engineering," the most complete book of its kind published. It will help you in your specifications.

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Friction Clutch Pulleys, Couplings, Quills, Operators, Clutch Sheaves, Floor Stands, Heavy Mill Bearings, Shaft Couplings, Sheaves and Tension Carriages, Pulleys and Fly Wheels.

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THE HILL CLUTCH COMPANY

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Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

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Speed Reducing Transmissions

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Specialists in cut gearing; spur, spiral, bevel, mitre, worms and worm gears, rawhide pinions, racks, incased worm gear reductions, O'K speed reducing transmissions 4:1 up to 1600:1.

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Manufacturers of Power Transmission Machinery and Sells Roller Bearings.

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Tanners—Belt Manufacturers. Output 100,000 Hides per year. Schieren's Duxbak Leather Belting is of two kinds, waterproof and steamproof, and is used for all belting purposes. Schieren's Bull's Head Belting for heavy drives. Schieren's Royal Extra Belting for general mill work.

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Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

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Papers on Power Transmission

PAPERS PUBLISHED BY A. S. M. E.

No. 1276. Symposium on Electric Driving in Machine Shop: A. L. DeLeeuw, C. Robbins, J. Riddell and discussion, price $1.10; No. 1335. Variable-speed Power Transmission: G. H. Barrus and C. M. Menly, price $0.10; No. S 17 X. A New Theory of Belt Driving: S. Haar, price $0.20; No. 1230. Transmission of Power by Leather Belting: C. G. Barth, price $0.50.

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ALLIANCE MACHINE CO.

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Makers of Alliance Cranes of all types; also Rolling Mill and Hydraulic Machinery, Steam Hammers, Punches and Shears, Scale Cars, Copper-Converting Machinery, etc.

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Punches and Shears

ALFRED BOX AND COMPANY

PHILADELPHIA, PA.

Electric and Hand Power Cranes, Portable Electric and Monorail Hoists, Complete Track Systems.

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Designers and Manufacturers of all kinds of Hoisting Machinery, including Locomotive Cranes, Electric Travelers, I-beam Trolleys, Crabs, Winches, etc., as well as heavy Hoisting Machinery of all descriptions. Also Ferroinclave for reinforced concrete roofing.

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Hoisting Machinery

H. W. CALDWELL & SON COMPANY

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Elevating, Conveying and Power Transmitting Machinery. Helicoid and screw conveyors, machine molded gears, pulleys, fly-wheels, rope sheaves and drives, sprocket wheels and chain, buckets, belting, shafting and bearings.

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Conveyors

Elevators

Power Transmission

CLYDE IRON WORKS

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Hoisting Engines and Derricks. All sizes and types of engines.

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Manufacturers of Electric and Belt Power Passenger and Freight Elevators, Hoisting Machines, Friction Winding Drums, Friction Clutches and Friction Clutch Pulleys.

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Manufacturers of Goodrich Conveyor Belt. The Goodrich "Longlife" "Maxecon" and "Grainbelt" Conveyors will handle more tons per dollar of cost than any other belt made.

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Coal Handling and Hoisting Machinery, Conveyors, "Industrial" Railways, Automatic Railways, Electric Locomotives, Storage Battery Industrial Trucks, Electric and Steam Hoists, "Stevedore" Manila Rope.

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Storage Battery Trucks

THE JEFFREY MFG. COMPANY

COLUMBUS, OHIO

Builders of Elevating, Conveying and Mining Machinery; Coal and Ashes Handling Systems for Power Plants; Screens, Crushers, Pulverizers, Car Hauls, Coal Tipples, Coal Washeries, Locomotives, Coal Cutters, Drills, etc. Complete Coal Mine Equipments.

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Hoisting Engines—steam and electric, for every use of the contractor, miner, warehouseman, railroad, shipowners, etc. Derricks, Derrick Irons and Derrick Hoists, Cableways for hoisting and conveying, Marine Transfer for coal and cargo handling.

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Elevators and Conveyors for every purpose; all accessories; Power Transmission Machinery. The Link-Belt Silent Chain Drive, Coal Tipples, Coal Washeries, Locomotive Cranes, etc.

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Conveyers
Automatic Elevators

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Manufacturers of Gravity Carriers, Conveyers, Spirals, Chutes, and Automatic Elevators. Engineering Department at your service.

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Grab Buckets
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The Robins Belt Conveyor was the original and is today the standard of this type of conveying machinery. It is successfully and economically conveying ore, rock, coal and similar materials under the most trying conditions of service. Correspondence invited.

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Manufacturers of Iron, Steel and Copper Wire Rope, and Wire of every description.

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SHAW ELECTRIC CRANE CO.

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Electric Travelers for all purposes. Gantries. Wharf Cranes. Railroad Wrecking Cranes. Mono-Rail Systems. Electric Motor Controllers.

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Toledo Cranes and Hoists; Coal and Ore Handling Bridges; Grab Bucket Machinery; Electric and Hand Power Cranes, all types, any capacity; Structural Steel for Factory Buildings.

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Rolling Mill Machinery

Engines, single and compound, Corliss reversing and blowing. Rolling Mill and Hydraulic Machinery of all kinds. Shears, Punches, Saws, Coping Machines.

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Foundry Molding Machine Equipment

Squeezing Machines, Hand or Power
Jolt Ramming Machines, Pneumatic or Electric
Split Pattern Vibrator Machines
Pneumatic Vibrators

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C. H. COWDREY MACHINE WORKS

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Contractors, Builders and Designers of Special Machinery.

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THE FELLOWS GEAR SHAPER CO.

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Manufacturers of Gear Cutting Machinery of the Most Advanced Type. In the Gear Shaper System a generating cutter is used which is ground after it has been hardened.

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St. Louis, 200 N. 3rd St.

Portable Electric Tools for Drilling, Reaming, Tapping, Grinding and Slotting.

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Manufacturers of a complete line of Plain and Universal Milling Machines, Screw Machines, Monitor Lathes, Tapping Machines, Duplex Drill Lathes, Speed Lathes, Cutter Grinders, Automatic Chucks, etc.

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Builders of High Grade, Accurate, Special Machinery, Fixtures, Jigs and Tools.

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Air Tools and Hoists

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Air Compressors, twenty standard types, capacity 8 to 9000 cu. ft. per minute; "Little David," "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity $\frac{1}{2}$ to 5 tons.

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Turret Lathes

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Manufacturers of the Hartness Flat Turret Lathe; made in two sizes for both bar and chuck work.

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Vertical Turret Machines, 28″ and 34″. Vertical Boring and Turning Machines, 42″ to 84″, inclusive

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CINCINNATI, O

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Engineering Specialties

Are the largest and best known distributors of Machine Tools in the world and carry in stock the product of the foremost designers of the many branches of machine tool building in the United States.

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BRANCH OFFICES:
NEW YORK CHICAGO DETROIT

Turret Lathes

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Electric Drive

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Generators

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Hoists

Fans

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Transformers

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Single-Phase Motors. Polyphase Motors. Transformers, Power and Pole Type. Instruments, a complete line. A. C. Generators. Converters for charging vehicle batteries from A. C. Rectifiers for charging small storage batteries from A. C. Train Lighting (Electric) Equipments. Automobile Self Starters (Electric), etc.

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